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NIELS RYBERG FINSEN

October 23rd, 1921, was the 25th year since the Finsen Medical Light Institute was founded, after FINSEN by a series of works had proved the enormous significance of light in medicine.

Even as a medical student FINSEN had begun to interest himself in light as a means of cure. From his earliest days he was delicate, and he himself believed that he suffered from anaemia, and therefore sought the sun, thinking that just as light was necessary to vegetation so it must also be beneficial to the human organism; and he made numerous observations which he later on developed, and which became the foundation of his works on light.

Immediately after his examination for the degree of Bachelor of Medicine FINSEN was appointed Prosector anatomiæ of the University, but he resigned the post three years later in order to devote himself entirely to the study of light, which was his real interest.

His ingenious foresight enabled him to perceive that here medicine presented an important field which no one had yet taken up, and where there was a possibility of breaking quite new ground.

FINSEN soon showed that he possessed rare ability for research, and he knew as no one else did how to draw conclusions from quite simple and ordinary experiments, and in the course of a few years he created the foundation for the light therapy which is now victoriously advancing over the whole world. In spite of his serious and often painful illness he worked with an energy such as it is the lot of few to possess, and to which the numerous articles which emanated from his hand in the course of a few years bear witness.

In July, 1893, FINSEN's first treatise on »the influence of light on the skin» appeared (Hospitalstidende 1893). In this work he developed the investigations of CHARCOT, WIDMARK and HAMMAR on

the ability of the chemical rays to produce inflammation in the skin, and he immediately drew therapeutic conclusions from his own investigations by advancing a proposal to treat small-pox by red light, viz. by light where all chemical rays are excluded. This treatment, which FINSEN called the Negative Photo Therapy, is based on the pernicious effects of the chemical rays on the organism, and was only a stage on the road to his real object, viz., to create by the utilization of the chemical power of light a therapy based on experimental investigations. Meanwhile it showed FINSEN's ingenious ability to utilize his experiments in every way for positive results.

FINSEN continued his investigations and published various scientific articles, of which I shall mention only his treatise on light as an irritant; a work which in a special degree shows his unique ability to make experiments and draw significant conclusions from his observations.

In 1896 FINSEN's best known work »On the Employment in Medicine of Concentrated Chemical Light Rays» was published. In this, on the basis of his numerous investigations as to the effect of light on the skin and bacteria, he proposed to employ the concentrated chemical light for the treatment of Lupus vulgaris.

The results from this treatment were so remarkable that light-treatment was soon introduced throughout the whole world.

During some years FINSEN was now occupied with improving his apparatus and perfecting his methods, but he always worked with the future in his mind's eye, and thought that the results he had hitherto achieved would be far surpassed by the therapeutic employment of the universal light-bath, and made a series of experiments with this in view.

Meanwhile his disease steadily grew worse, and he died without winning victory for the chemical light-bath. Not till years after his death was it proved how foresighted he had been, for today the value of the ordinary light-bath in the therapy is generally recognized, and has, so to say, far greater importance than the treatment with concentrated chemical light.

In the course of his short lifetime FINSEN succeeded by means of his experiments in founding the light therapy, but his greatest importance as a pioneer in medicine undoubtedly is this, that he introduced quite a new therapeutic principle, of which the scope was not clearly to be perceived, and cannot even yet be estimated. There is no doubt whatever that FINSEN's work brought about the very prompt testing of the healing effect of the roentgen and radium rays, and that his work has been of the greatest possible importance for all modern radiotherapy.

FINSEN knew, as few do, the art of inspiring his staff and pupils so that they co-operated with delight and energy in the matter which interested him. He had an incitative influence not only on his near surroundings, but also far beyond the borders of Denmark, and his investigations as regards light produced a numerous succession of works on this subject.

As the ingenious investigator that he was, FINSEN looked far into the future, and he understood that the new ground he had broken in the science of medicine was of such significance as no one could realize.

His age, indeed, hardly understood the scope of his work, which continues even now, many years after his death, to bear new fruit.

A. Reyn.

FINSEN'S MEDICAL LIGHT INSTITUTE

1896—OCTOBER 23—1921

by

C. E. Christensen

Superintendent of the Institute

FINSEN prefaced his first report on the activity of the Light Institute with the following words: »This is not a report on a steady, firmly established undertaking but on one which is in a state of constant and rapid development, and still far from its culmination.»

Even after the course of 25 years the activity of the Institute has not ceased, as it still is in a full, vigorous state of development; and though events do not succeed one another so closely as in the first happy years when FINSEN himself steered with a fair wind towards his lofty aim, yet, had he been alive today he would have been fully justified in repeating the words of his first report, and might with pride have pointed to the fact that of all the more important results obtained at the Institute hardly one is to be found which was not directly arranged by him during the short period in which he was allowed to conduct the Institute.

FINSEN's fundamental experiments, whereby he succeeded in proving the effect of light on various living organisms are known to a great part of the world, and will not, therefore, be mentioned here.

That the exclusion of the chemical rays of light (the red room) meant that small-pox was cured more rapidly and without leaving scars he had opportunity to prove in 1894 at the *Öresund Hospital*, where an extremely sympathetic and comprehending attitude had been adopted towards the young, and at that time quite unknown doctor; and when in 1895 he wished to try the effect of the electric carbon-arc-light on patients suffering from lupus, it was quite natural that he should again apply to one of the municipal institutions of Copenhagen, and this time to the electric-power station in Gothers-

gade, where he met with the greatest assistance from the manager, WINDFELD-HANSEN, later Director of Lighting, and from his staff.

In November 1895 the experiments began with one patient, a Copenhagen engineer and manufacturer, who soon became one of FINSEN's most faithful friends, and later a member of the Institute's Board of Directors, where he sat until his death a few years ago. He submitted with rare patience to the protracted treatment, while the manager and staff of the power station vied with one another in assisting FINSEN to produce new and improved apparatus for the treatment.

In February 1896 this patient was practically cured, and as FINSEN had at the same time carried out the treatment of another lupus patient, with concentrated sunlight, WINDFELD-HANSEN thought that the time had come when the experiments might be established on a broader basis.

From conversations with FINSEN he knew that the latter dreamed of the establishment of a light-laboratory, with the *Pasteur Institute* as a model, where he could continue and develop his experiments, and from where he could disseminate his results the world over, for the benefit of many afflicted and suffering human beings.

WINDFELD-HANSEN saw that for this two things were needed, money and influence; and it was his great merit that he found a man who not only had money and influence but also immediately perceived the ingenuity in FINSEN's idea that light could have a healing effect.

It was to G. A. HAGEMANN that in Feb. 1896 WINDFELD-HANSEN applied, asking him to interest himself in the young doctor who believed so implicitly in light as a means of cure.

HAGEMANN, at the time, was rather worried by projectors, and would have nothing to do with the affair, but WINDFELD-HANSEN, who knew by experience FINSEN's unique gift of convincing people of the correctness of his theories if only he could get into conversation with them, finally asked HAGEMANN at least to receive the young man, when after hearing him he could dismiss him without in any way committing himself. When HAGEMANN at length consented, WINDFELD-HANSEN, who was well aware of the former's quick apprehension and sharp eye for the practical, knew that FINSEN's business was in good hands.

Next day FINSEN visited HAGEMANN in his office, where he gave a verbal sketch of his experiments and of plans for the future. HAGEMANN listened with interest and attention to FINSEN's development of his ideas, and then asked for a statement in writing.

About March 1896 HAGEMANN received from FINSEN a conspectus

of the method and treatment, including what was needed for this, and accompanied by a letter in which FINSEN writes, amongst other things:

»I have been rather perplexed as regards the statement, for which reason you receive it rather late, as it is advisable that a number of reliable results should first be forthcoming, though, on the other hand, such an institution should even now be considered, in order that the whole arrangement shall not be provisional. This incongruity has greatly troubled me, and I have therefore seen fit to make the statement on two separate sheets, each with its main consideration.»

These remarks are characteristic of FINSEN. On the one hand his great modesty — his wish that no great sum should be expended on the affair until he is able to support his theory with a number of reliable results — and on the other hand his firm belief in the ability of light to heal, which tells him that without any doubt an establishment for treatment will be wanted along with the laboratory. From his modesty and his sober view of his own discovery arises the wish that nothing shall be built which in the course of a short time may have to be removed as useless.

FINSEN did not forget the sympathy he had met with at the *Öresund Hospital* and at the power station in Gothersgade. Now, also, he placed his trust in the Municipality of Copenhagen. To HAGEMANN he wrote amongst other things: »It would be of great assistance to me if the Municipality would give me some support, for example, a plot of ground for eventual barracks and power for the electric lamps. I might perhaps be able to make a slight return by treating the Municipal patients gratis.»

Evidently HAGEMANN very quickly let himself be convinced as to the correctness of FINSEN's representations. He applied to a number of persons who either had already been in communication with FINSEN, such as Professors FEILBERG and HASLUND, as also WINDFELD-HANSEN, or who might be thought willing to support FINSEN in the work which was now forthcoming, for example his close friend and fellow worker, and later Councillor, VILH. JØRGENSEN, MAYOR BORUP, and GREDSTED, inspector of the Municipal Hospital, and as early as April 29, 1896, these — 13 in all — together with FINSEN met in the MAYOR's office in Copenhagen Town-hall.

The MAYOR offered to place a site in the Municipal Hospital garden at their temporary disposal, for the erection of a small building to be used as a light-laboratory, and for the rest to support the affair with certain means at the disposal of the hospital, if others would provide funds for the building and apparatus.

HAGEMANN announced that there was a fair prospect of the

Carlsberg Fund adding its support in the following autumn, and it was resolved:

(1) To appoint a committee to arrange a temporary, small laboratory for experimenting; to consist of JØRGENSEN (treasurer), JUHLER, WINDFELD-HANSEN, MOGENSEN, GREDSTED, and Professor HASLUND.

(2) To appoint an organizing committee with the object of arranging the details and administration of the concern. To this were elected BORUP, Prof. LANGE, GREDSTED, Prof. HASLUND, and HAGEMANN. The latter being authorized to apply for pecuniary assistance from the Carlsberg Fund and similar institutions. BORUP, however, did not wish his name mentioned in this connection.

It was certainly not due to chance that VILH. JØRGENSEN became Treasurer of the Institute, and the one member of the Board who was in closest touch with its daily life and work. Even before HAGEMANN mentioned FINSEN to him, he knew him by report, and FINSEN's discoveries had roused his keenest interest, which interest he has faithfully kept alive till the present day. For many years he daily visited the Institute, where he was a splendid support first for FINSEN, and later for the other managers, and where by personal pledge he steered the Institute past many dangerous reefs.

The arrangement between the Municipal Hospital and the light-laboratory was quickly adjusted, and just as FINSEN had thought it out. A wooden building was immediately started in the corner of the hospital garden formed by Gammeltoftsgade and Østersøgade.

On August 10, 1896, the building was in all essentials finished, and a meeting was held in the new building, where it was resolved to commence work at once.

The whole concern was extremely small and modest, as FINSEN had wished. The cost of the whole building was Kr. 4,331.15, and all the fittings of the laboratory Kr. 1,407.81.

It had been FINSEN's original idea that the treatment should be carried out principally with the assistance of the patients' relatives, as he thought that the technique was so simple that anyone, even without any special qualification, would be able to acquire it. At the meeting on August 10 it was nevertheless resolved temporarily to engage one lady to assist with the treatment, and another later, at a wage of Kr. 12 per week. Although today the remuneration seems fabulously small, yet it must have been too high, as even in the estimates for 1897 it was reduced to Kr. 8 per week.

It was further resolved to engage a charwoman at Kr. 10 per week, and a young physician at Kr. 70 per month. FINSEN himself was to receive nothing for his work.

On August 25 FINSEN could show his light-laboratory to his 13

fellow founders. At a meeting then held, HAGEMANN announced that Messrs. G. TVEDE, KARSTEN, and WINDFELD-HANSEN had kindly assisted the committee in erecting and fitting up the building, and that the Carlsberg Fund had promised to contribute Kr. 2,000—2,500.

On the proposal of BORUP it was resolved to call the establishment »Finsen's Medical Light Institute».

The real founding of the Institute took place at a meeting on October 23, 1896, when the 14 men who hitherto had worked for FINSEN's cause passed regulations, and constituted themselves the Board of the Institute. Officials were elected and a committee to conduct the working of the Institute.

In addition, estimates for the year 1897 were passed, which balanced with Kr. 8,250.

It was now expected that there would be space for 24 patients, but a daily average of only 18 was counted on, and of these only 7 with full payment.

In view of this anticipated rise in the number of the patients it was considered that there would be work for six female assistants, but their wages, as stated above was reduced to Kr. 8 per week.

The work at the Institute now proceeded with a display of extraordinary energy. The Board itself worked no less energetically, and under the influence of FINSEN's personality and firm faith, and of his richly productive work, soon felt assured of the healing ability of light.

On June 2, 1897, it was resolved to approach the Government with a petition for a grant of Kr. 20,000, from the revenue for the Financial year 1897—98.

The petition which, in conformity with the conditions then prevailing, was directed to the Ministry for Ecclesiastical and Scholastic Affairs, was encouraged partly by the strong faith of the committee in FINSEN and his theories, and partly by a patriotic wish to secure for Denmark a leading place in the domain of light-treatment.

In order that the outcome of the petition might be favorable, the committee was divided into groups, which should severally seek audience of the Minister, the Leaders of the two Houses, and of the Finance Committee.

At the request of the Minister, FINSEN later sent in a proposition as to the disposal of the Kr. 20,000 applied for.

The document evinced remarkable foresight on the part of FINSEN, as he gave on a large scale the lines which the work of the Institute has followed during the past 25 years, and which it still follows steadily.

He divided his estimate into 3 groups.

a. Expenses for new supplies, and for continued scientific experiments as regards the treatment of disease with concentrated chemical light-rays.

b. Expenses for experiments intended to be made with general light-treatment (light-baths) of various affections, especially common tuberculosis, chlorosis, and debility with anæmia.

c. General expenses important for both *a* and *b*.

As regard *a* FINSEN thought of the local light-treatment, which seems to have particularly attracted his interest. In any case he had time before his death not only to indicate the technique, but also, with the present Dr. REYN, to construct the apparatus as at present employed.

Point *b* concerns experiments with light-baths. Even when treating his first patient at the power station in Gothersgade FINSEN tried to expose the patient to direct lighting of the entire body from an electric carbon-arc-lamp, and when he saw that the patient became pigmented, i. e. sun-burnt, he concluded that the method might be employed with various diseases. He did not live to carry out these experiments, but his estimates show which diseases he had thought of treating. When, many years later, Dr. REYN resumed the experiments, he succeeded in proving that FINSEN was right, and now different forms of tuberculosis are most successfully treated with electric carbon-arc-light baths, not only everywhere here in Denmark but also in numerous places in Scandinavia and other parts of the world. The development of the Institute was so rapid that at a meeting of the committee on May 17, 1897, FINSEN had to ask for more room. The work at the laboratory could only with difficulty be carried on at the existing premises, and patients could not be received for treatment to the necessary extent. It was chiefly severely attacked patients who had suffered from the disease (lupus) for many years who found their way into the Institute, and for this reason the cures had to be protracted. Although work was maintained uninterruptedly from 7 a. m. till 7 p. m. and the space was used to its utmost, only 25 patients could be treated daily. At this period 75 patients were announced whom it was impossible to treat.

That FINSEN's fame had even then begun to spread beyond the confines of Denmark was proved by 11 of those patients having come from abroad.

The grant of Kr. 20,000 already mentioned had been voted by both Houses, and it was therefore decided to arrange the first building as a laboratory only, and at the same time to erect a new building for the treatment. According to FINSEN's proposal this should contain one room for local light-treatment with 4 electric

lamps, each for 4 patients; one room for electric light-baths; and also cells for sun-baths.

In the course of the summer the building was erected, and on December 14 it could be used.

From June the hours of treatment had had to be extended till 10 p m., at times till 11 p. m.; and at the same time it had proved necessary to shorten a great number of the séances from 2 hours to 1 hour.

These long daily working hours had to continue till November, but the reduction in the duration of the séances was continued till later, when it was decided to divide the working day into six séances of 70 minutes, which division is still employed.

In October 1897 the committee realized Finsen could not continue to devote all his energies to the Institute without receiving any recompense, and it was resolved to give him an honorarium of Kr. 1,500, out of the net profit of the year, the existence of which, however, was rather problematical, as everything that could be scraped together in the way of money was employed to improve apparatus, etc.

It certainly could not have been agreeable to Finsen to receive payment for his work, because when he was asked to decide what his future remuneration should be he proposed Kr. 2,000, but at the same time regretted having to accept the money, and expressed his readiness to content himself with any lesser sum whatsoever.

Hagemann and Jørgensen, who both nourished the greatest admiration and devotion for Finsen had at the end of 1896 paid the whole debt of the Institute, including the amount expended in erecting and fitting up the building. Now, in October 1897, they saw that if the Light-Institute was to succeed in becoming what both they and Finsen believed and wished, the Institute would have to have much more space than the Municipal Hospital garden could afford. They clearly saw what the development would demand, and knew that prompt measures were called for.

On their own initiative they sought for a property suited to their purpose, and found one in the large villa plot No. 37 on Rosenvængets Hovedvej, belonging to the heirs of Hinné the Circus Director.

They offered to purchase the large site of 85,440 square feet for the Institute, advancing the necessary sum until the end of the year 1899, which was the latest date when it could be decided to what extent the Institute should acquire the property, and the Board unanimously accepted the offer.

At the meeting of the Board held on Jan. 11, 1898 the Chair-

man was able to report that FINSEN had been appointed Professor, after which HAGEMANN moved a petition to the Government for a grant from the Exchequer for the erection of a permanent building for the Light Institute on the property in Rosenvænget.

The work had now increased to such an extent that the temporary premises were quite inadequate, while the results obtained were such as to fully justify the establishing of the Institute on a more stable basis. Finally there was a prospect of the Municipal Hospital itself in the near future requiring the site which had temporarily been placed at the disposal of the Institute.

It was resolved to forward the petition, but when this had been done, the Department for Ecclesiastical and Educational Affairs reported that the time was too far advanced for any grant under the Budget 1898—99 to be possible.

The postponement undoubtedly was unpleasant, not only for FINSEN but also for the patients, and for one and all who were connected with the Institute. But it had this advantage, that, when in September 1898 the petition was repeated, what was needed, and what the authorities might be expected to agree to — a free loan of Kr. 240,000 — was fully realized, and FINSEN was also able to express himself far more definitely on the light-treatment. Appended to the petition he wrote, amongst other things: »I can certainly say that we have here got an absolutely effective method of treating lupus vulgaris».

— The appendage was characteristic of FINSEN, in that he makes no mention of himself, but everywhere uses the term »Institute» or »We» when it is a question of work done or results obtained.

Meanwhile FINSEN's already delicate health had deteriorated. So far he had kept on by displaying wonderful energy, but he saw where it all must end, and therefore took steps to ensure the work and its management being carried on by others after him; transferring the management of the laboratory and the treatment of the patients to Doctors S. BANG (late Professor and head surgeon of the Municipal Hospital) and H. FORCHHAMMER respectively.

On December 11, 1898, for the first time, he had to absent himself from the Board, being ill and confined to bed, though, nevertheless, by no means idle. From his bed he sent the meeting a report on the activity of the Institute during the period Sept. 1897—Oct. 1898, in which simply and unaffectedly he related his efforts to treat as many patients as possible in the extremely poor and cramped conditions. Though the report is short one gets a vivid impression not only of the immense difficulties with which he had to

contend, but also of his unique gift of making each of his assistants believe in and be enthusiastic for the cause.

The report which, amongst other things, went to prove the reasons for his having had to concentrate on the treatment of lupus was accompanied by a summary of the changes and improvements introduced at the Institute in the course of the year, and though the means were small and the space extremely limited, FINSEN had succeeded in so arranging matters that the number of patients who could be treated had risen from 32 in October 1897 to 112 in October 1898; a rise therefore of not less than 250 %.

It has been shortly mentioned in the proceeding pages that FINSEN wished his discovery of the healing properties of light and his method of light-treatment to become the common property of the whole world. The outcome of this humane thought was that he produced and forwarded apparatus for treatment to all hospitals and sanatoriums which expressed a desire for them the world over.

At the end of Oct. 1898, apparatus had already been sent to, or was being produced for, *Sweden, Finland, Russia, Austria, Hungary, Greece, Egypt, England, France, America, Germany.*

When it was remarked for what purpose HAGEMANN and JØRGENSEN had acquired the property in Rosenvænget a strong movement of opposition was begun amongst the householders to prevent the Light Institute being placed there. It was partly the greatly exaggerated fear of infection which even earlier in the year had found expression in a violent and strange manner (to be mentioned later), and partly that the sight of so many people with more or less disfigured faces offended the aesthetic sense, which caused the population of Rosenvænget to protest. They went so far as to try to persuade the Committee of Ways and Means to refuse the grant of Kr. 240,000 which was necessary to adapt the property to the purpose. But as only 3 members of the Committee voted against the loan this was granted in spite of the protest of the landholders; and as the Board of the Institute refused the offer of another property together with a sum of money as compensation for the advantages of the property in Rosenvænget, the movement gradually died down.

By degrees the conditions at the Institute became quite intolerable. In April 1899 there were 150 patients under treatment, but there were about 200 on the waiting list.

In order to make more room for the treatment FINSEN proposed to move the laboratory and the light-baths to Rosenvænget, and to utilize the premises hitherto used for light-baths for local light-treatment, and the laboratory as a consulting room.

The committee handed on the proposal to the Board adding that the laboratory should be installed on the ground floor of the villa, while FINSEN had his quarters on the first floor. It was proposed to locate the light-baths in a riding school already on the premises.

With the consent of the Mayor of Copenhagen a special electric wire was laid from the power station in Gothersgade to Rosenvænget, but not until January 1911 could Finsen and the laboratory move in.

Meanwhile the free loan from the Exchequer had been granted when, in addition to the riding school which was transformed into a ward for light-treatment, the erection of a clinic and executive buildings was begun in Rosenvænget.

On August 10, 1901, the Institute was able to move into its own premises, and the connection with the Municipal Hospital which had been of great benefit both to FINSEN and the Institute ended.

The arrangements of the new property are so well known to many people that it is not thought necessary to give an account of them here. Later one of the barracks from the Municipal Hospital was removed to Rosenvænget, where, until the spring of 1920 when it had to be pulled down to make room for a new engine room, it stood as a visible reminder of the first modest beginning of the Institute.

The purchase of the property together with the installation of the laboratory and the erection of the new building had cost Kr. 365,000, or Kr. 125,000 more than the sum at disposal.

Here HAGEMANN and JØRGENSEN again came forward with their assistance, and advanced the necessary sum to the Institute.

As, after the move, the management of the Institute became much more costly, seeing that the support which the Municipal Hospital had in so many ways and so generously afforded was wanting, and as, owing to the poverty of the majority of the Danish patients, the fees for treatment had begun to be reduced to such an extent that the receipts as compared with the normal estimates were diminished by Kr. 42,000, while at the same time the working expenses of the laboratory had risen to Kr. 15,000 yearly, the Board transmitted to the Ministry for Culture a petition both for a new loan of Kr. 125,000 free of interest, and for a yearly contribution of Kr. 25,000 to meet the expense of free or partly free treatment.

As regards the first point the petition was not successful, but the Kr. 25,000 requested as a fixed yearly contribution was granted under the Budget 1902—1903. From the Financial Year 1905—1906 this grant was raised to Kr. 30,000 yearly, essentially for the purpose of paying the travelling expenses of lupus patients under observation,

and who were called up for inspection during the first 5 years after the principal cure.

From the Financial Year 1914—15 the grant was raised to Kr. 40,000 annually, and from the year 1921—1922 it ceased, owing to lupus being included in the Tuberculous Act.

It has been mentioned above that in the year 1910 the Institute sacrificed Kr. 42,000 by treating poor patients at reduced fees. If the sum was no larger this was partly due to legacies and gifts which the Institute had received for the patients, but especially to the »Society for Assisting Needy Lupus Patients» founded by H. P. B. Jacobsen, Th. Mogensen, and E. F. Christensen. In this way Kr. 11,669.11, or 19 % of the aggregate receipts of the Institute was obtained during the year mentioned, of which Kr. 6,750.52 was from the above mentioned Society. The Society lasted until May 1902, and during its short existence collected about Kr. 36,000, which was spent on the treatment of poor patients. Thus it had greatly benefitted the Institute and the patients, and was only dissolved because § 61 of the Poor Law, which treats of the support which the Municipalities may give to certain sick people without the assistance having the effect of Parish Relief, was extended in March 1901 to comprise lupus patients.

This amendment of the law, in connection with the fixed Government contributions which had been granted had, moreover, the regrettable effect that other private charity was withdrawn from the Institute.

The economic conditions of the Institute had never been good, but thanks partly to the energetic work of the Directors in getting grants from the Government and from various benevolent societies, and partly (though not least) to Hagemann's and Jørgensen's great self sacrifice, it had succeeded in coming through the first years fairly well. But from the moment when the Institute was removed to Rosenvænget its economic difficulties began to assume a more serious character.

The purchase and alteration of the property had cost, as above mentioned, Kr. 125,000 more than had been calculated, and the authorities had refused the free loan for this amount. Far the greater number of the patients (the Danish patients not less than 85 %) had to be treated for moderate fees or gratis, and it did not help much that by the mentioned amendment of the Poor Law the Municipalities were obliged to pay for poor lupus patients, because a number of the Municipalities lacked the means to defray the expenses of the protracted treatment; and to get the patients under treatment at all, the Institute had to continue to work to a great extent for reduced

payment. When at last private benevolence failed, FINSEN, though by nature enthusiastically optimistic, began to view the economic condition of the Institute with less confidence. From 1901 he constantly called the attention of the Board, orally and in writing, to its poor economic condition. He greatly appreciated the large sums which HAGEMANN and JORGENSEN had advanced to the Institute, but regretted at the same time that the Institute was unable to cover them. It helped somewhat that in 1903 FINSEN succeeded in getting a permanent grant of Kr. 10,000 per annum for 3 years from the funds of the Community for Scientific Research, but new sums for improvement of apparatus and for new experiments were constantly demanded.

Thus, in 1902, an expensive renewal of the light-collecting apparatus was carried out, and at the same time the method for cooling with water the lense of the apparatus nearest the lamp, as indicated by Reyn, was adopted. On the other hand this brought about a significant saving in working expenses, as the lamps now burn with a current of 50 ampère as against 60—80; and in 1903 a considerable part of the Community's grant was spent on the erection of a stable for investigating the physiological effect of the different parts of the spectrum.

It was only natural to try to economise in the working expenses, as for instance in the above-mentioned saving in the consumption of electricity, and another item was the erection of its own dispensary. So long as the Institute was situated in the Municipal Hospital grounds this hospital, in accordance with agreement, delivered free of charge all the medicine which the Institute used. With the move to Rosenvænget this ceased, and the Institute was reduced to purchasing its requirements from one of the town chemists, which was expensive, and also in other respects considered less suitable, and not quite in accord with the Institute's interests. In 1902, therefore, the Institute petitioned for, and obtained, the permission of the Ministry of Justice to dispense medicine, on the condition, amongst others, that a pharmaceutist was appointed to carry out the dispensing. This has since proved of great benefit to the Institute, and gradually, as the consumption of medicine increased, great sums of money have been saved.

It cannot be sufficiently emphasized that in this and other efforts te economize FINSEN always had two things in his mind's eye; that neither the patients nor their treatment must suffer in any way whatever thereby, and that the reliability of the results obtained must not be impaired.

In the autumn of 1902 FINSEN was very ill. In November his

condition was for a time so serious that those about him, and he himself, expected that he would die.

On November 11, at 5 a. m., he dictated his Will, his last wishes with regard to the future of the Institute — It reads as follows:

»If I should die before Dr. Busck[1] is firmly settled I should prefer that no decision as regards the laboratory is made for the moment, but that my place shall be taken by Jorgensen and Dr. Forchhammer conjointly, or by Jorgensen alone, as it is a matter of course that the latter will always confer with Forchhammer as the manager of the clinic. If there has to be another member of the laboratory committee I would propose Professor Haslund as one who has a sound and free view of affairs. With all due respect to the men of science proper (Professors of the University) I would rather that they should have no influence on the laboratory. Perhaps this is an oddity on my part, but although many of them have shown me every possible kindness, geniality, and appreciation, the whole work and way of working of the Institute has no doubt not been to their liking. It is difficult for me to express just what I mean, but it is a little on the lines of the contrast between the authorized and the unauthorized. That which for so many is the one thing necessary for salvation, the formal, academic, etc. stamp has always been extremely distasteful to me, and I should not like this stamp to be laid upon the Institute too soon. I understand, naturally that some day it must come, but wish that this may be as late as possible. I have always tried to break down authoritative belief, in myself also, and have tried to make my fellow-workers work as independently as possible; first of all to believe in themselves and what they themselves have seen, then in their fellow-workers, next in those they know a little about, and least in those of whom they know nothing, but who, just because they are foreigners or university men are often regarded as authorities, or credited with an importance which would not be given to them if they were known.»

Finsen did not die that time, but he never changed one iota of this his fundamental view of science.

It has been previously stated that the Institute developed with extraordinary rapidity, but this undoubtedly did not accord entirely with Finsen's wishes. Reliability and sobriety formed a pronounced feature in his character, and nothing was further from his thoughts than to force the development at the cost of reliability.

This feature in his character evinced itself very strongly in a

[1] Gunni Busck whom Finsen valued greatly as a scientific co-worker, and as a man, and whom he had indicated as the conductor of the laboratory after his death.

communication which he wrote to the Board in November 1903, in which, amongst other things, he said »In one way the Light Institute occupies a rather peculiar position: at the same time that we form the centre from which all light-treatment has originated, and may still be said to preserve the leadership in the domain of light, yet we have been far outsailed by doctors all over the world, and in all directions. Soon there will not remain one thing not treated with light or witht the nearly related ROENTGEN or BECQUEREL rays (radium), and the results are generally described as wonderful. It might now be thought that the principle which we correctly follow, and have followed since the founding of the Institute, viz., not to worry if things progress slowly so long as what we say is reliable, it might now, as I say, be thought this point of view does not suit the present age, when everything proceeds at full speed, but, quite the contrary, the principle has proved excellent, perhaps because it differs so from the common. It is enough, in any case, that the Institute has been fortunate enough to acquire a special and unique reputation for reliability. I have allowed myself to mention this so explicitly to the Board partly because I wish that in the future also this principle shall be honoured in the Light Institute as a particularly good and auspicious tradition, and partly as an explanation why, in order to carry out this principle I have sometimes had to use an apparently hard hand.»

In the following month, December 10, 1903, FINSEN attained the zenith of his fame, as on that day he received news that he had been awarded the yearly Nobel Prize for medicine, Kr. 150,000.

This afforded the finest expression of his great disinterestedness, inasmuch as he who had hitherto been fortuneless wished the money, or part of it, to be applied to freeing the Institute of debt.

He was permitted to present his dear Light Institute with one third of the Prize, but the Institute was entirely freed of its debt, as his two faithful and ever generous friends HAGEMANN and JØRGENSEN each contributed a corresponding sum.

Being an easily contented and modest man, with few personal requirements, FINSEN could not think of retaining the rest of the Prize, so used yet another third for charitable purposes.

The directors and doctors of the Institute met in FINSEN's home in Rosenwænget, and having received their congratulations FINSEN replied in a speech which deserves to be known because it shows his rare humane quality. Having expressed thanks for the congratulations he answered as follows:

»If I considered the Nobel Prize to be an honour shown to me personally I could not accept these congratulations. Because the

work rewarded is due only in a small degree to me. It is a common work performed by the directors, doctors, and staff of the Institute, with the outside support of the State, Municipality, Institutions, and of private people. I regard it in this way, that the Nobel Prize has for the greater part been conferred on me as the medical representative of the Light Institute, and as such it is a joy and a pride for me to accept your congratulations. For the Light Institute the Nobel Prize awarded is of invaluable significance. It gives to an Institute which is still quite young and is built on new ideas, a world recognition than which no greater can be desired.

It is now my greatest wish that the Light Institute may understand how to make use of the happy event.

The Institute is still in its infancy, and there are many important problems which await their solution: here I am thinking especially of the general effect of the light on the organism.

For the last year or two, moreover, the Institute has not been uninfluenced by economic worries, and therefore has been somewhat hampered in its progress. Would that the Nobel Prize might prove the impulse for the Institute to develop and become great and powerful, so that with dignity and strength it can strive to fulfil its great task: the investigation and employment of that immense natural power, the life bringing light-rays.

The Nobel Prize carries honour and money. Would that the Light Institute might understand to make use of the honour received in the right way, would that it might understand that honour imposes obligations, that it imposes the obligation which I reckon the highest in all science, viz., veracity, reliability, and cool, sound criticism.

Would, also, that the money might benefit the Light Institute, and serve to promote its object. I accept it as a good omen that the first effect of the Nobel Prize and of my provisional contribution is that the Institute, with the assistance of HAGEMANN's and JØRGENSEN's great and significant gift, has been freed from debt. On behalf of the Light Institute I convey to these two gentlemen my best thanks for this new proof of their great affection for and interest in the Institute.

I cannot conclude my remarks better than in proposing what we can all join in — success and prosperity to the Light Institute, our love and our pride.»

Later in the day FINSEN and his staff assembled in the clinic of the Institute, where he received the homage of those whom he regarded not only as co-workers but also as friends, and with whom he magnanimously shared the honour of what he had attained up to that day.

But FINSEN was marked by disease. His heroic fight against this and his wise, acute observations during the whole course of his illness has been so well described by the late editor W. THULSTRUP, that it could scarcely be done better. Here will only by emphasized that he continuosly had his attention fixed on the general effect of light on the organism. In his above-quoted speech he also entered upon this question, which had evidently occupied his mind considerably, and in the summer of 1904 he worked out, while lying on his bed, a proposal for the erection of a sanatorium, with the study of the general effect of light for its object; which he sent to the Board.

This voted the support of the plan, but FINSEN did not live to see it realized.

ON SEPTEMBER 24, 1904, FINSEN DIED

What the Light Institute and the whole Danish nation lost by FINSENS' premature death cannot be measured. One can only regret that this ingenious investigator was not allowed to complete the work of his manhood. Although in his short life he had already done more than is allotted to most, he regarded his main work, the Light Institute, as a concern which was still in its infancy, and his thoughts continuously circled round all the different problems which awaited solution.

But he had long been reconciled to the thought of having to leave his plans for the Institute as a legacy to others. This evinced itself, amongst other things, in the previously mentioned communication to the Board in November 1900, in which he worked out what he wished should be the future leading principles of the Institute, and in his Will; and on the last day of his life he expressed to his fellow workers his thoughts and wishes as regarded the future of the Institute. He wished to express his views to his friend, VILH. JØRGENSEN, but he knew that death was near, and he feared that JØRGENSEN would arrive too late, so he begged his fellow-workers to repeat the main points of his conversation. They are written down and read in excerpts thus: he emphatically indicated Dr. BUSCK as conductor of the laboratory, but hesitated a little for words in which to characterize him, and ended by saying: »BUSCK is to me like a son — spiritually spoken.» When it was suggested that he could not mean BUSCK to take over the appointment at once, and that he ought to be given opportunity to develop and prove his ability, FINSEN nodded and said »Yes, there is no hurry». The sanatorium, also, was greatly on his mind. He main-

tained that it might become of great importance for the Institute, and also emphasized that Dr. JACOBÆUS's knowledge and sagacity might be of great benefit to the Institute. He added, however, that here economic interests must be the decisive factor — it was of vital importance for the Institute to become economically independent.

With FINSEN's death a new epoch began for the Light Institute. As long as he lived it was his ingenuity, initiative, and wealth of ideas which gave prestige to the Institute, just as it was his enthusiasm and love for the »light problem» in connection with his sound sober criticism which made his fellow workers render the best of their ability.

Would his successors be capable of receiving the legacy after him? This was the great question which at once presented itself.

The events which succeeded FINSEN's death are so near the present day that it is impossible already to pass a just sentence. But here it must be said that the directors as well as the staff, each to the best of his ability, tried to act in the master's spirit.

In this way the Board continued the work, interrupted by FINSEN's death, for the establishing of a sanatorium with the »general effect of light» for its object, which finally led to the establishing of the »clinic for internal diseases».

The history of the birth of this was shortly thus: It is known how FINSEN's severe illness led him on to the study of dietetics. During the last 4—5 years of his life he tried by exercising a strict diet to adjust his consumption of food in accordance with the secretive ability of the organism. When he, great philanthropist that he was, wished to put his experiences in this domain at the disposal of other sick people, and mentioned this to his two friends, HAGEMANN and JØRGENSEN, they at once expressed their willingness to support him. In 1901, at their own expense, they opened a sanatorium for diseases of the heart in »Gl. Vartov» on the Strandvej.

After FINSEN's death Dr. K. HASSELBALCH was appointed director of the laboratory, where, following FINSEN's thoughts about the general effect of light on the organism, he performed a series of investigations by which he succeeded in proving a reduction in the blood pressure, and in connection therewith an easing of the action of the heart with people who were treated with electric carbon-arc-light baths. Through this he created the theoretic foundation of the employment of the light-bath as a remedy for heart diseases, and on the basis of this, on January 17, 1906, the Board decided to establish a light clinic for diseases of the heart.

It was thought that the necessary funds would be procured partly

by petitioning the Exchequer for a free loan, and partly by applying to the committee of the FINSEN memorial fund, which had been formed immediately after FINSEN's death, with the two-fold object of procuring means for a visible memorial and of supporting the work of the Light Institute. Finally HAGEMANN, on his own and JØRGENSEN's account promised the affair their support if necessary.

In order to procure a serie of suitable experiences as regards the indications and technique of the method, it was further decided to establish a provisional light clinic of 10 beds in FINSEN's former apartments. On May 25, 1906, the clinic was opened, and on November 1, of the same year, the sanatorium for heart diseases privately established by FINSEN together with HAGEMANN and JØRGENSEN on the Strandvej was abolished.

On November 10, 1906, Mrs. FINSEN laid the foundation stone of the new clinic for internal diseases after the necessary building funds had been procured in the following manner. The committee of the FINSEN memorial fund gave a contribution of Kr. 50,000, while the State undertook the amortization of a mortgage of Kr. 160,000, and finally the two benefactors of the Institute again gave Kr. 50,000 each.

On April 1, 1908, the clinic for internal diseases was opened, and at the same time the provisional clinic was abolished.

As the above-mentioned building sum had proved insufficient, the Exchequer undertook the interest and amortization of a further mortgage of Kr. 60,000.

In accordance with wishes which came to light after FINSEN's death a small *Finsen Museum* was arranged in the clinic building, to which Mrs. FINSEN presented a number of the articles which her late husband had used during his lifetime.

As regards the *Finsen Memorial Committee* it must here be said that it received an extraordinary response both from the population here in Denmark and from abroad. From high and low, from far and near, the contributions poured in, and when the committee published a »*Finsen-stamp*» which was sold in thousands all over the country for 10 'oere', one dared conclude that practically every Dane then living had given his large or small contribution towards the memorial to this famous son of the nation. But it was a mistake, which was of benefit to nobody and nothing, when the monument was not placed in one of the spots where FINSEN had lived and laboured. A mistake which, however, was rectified in the nicest way when Councillor VILH. JØRGENSEN, in 1912, presented the Institute with the *statue of* FINSEN sculptured by his son, VIGGO JARL,

which found its natural place in the Institute garden, in front of the entrance from Rosenvængets Hovedvej.

After FINSEN's death the work both in the laboratory and the clinic for skin diseases ran its steady, quiet course. Apart from HASSELBALCH's investigations into the general effect of light, which led to the establishment of the clinic for internal diseases, nothing of great scientific importance occurred for some years.

But in another domain, the care for lupus patients, much good and energetic work was done.

In spite of his attention being so taken up by his great scientific work, and in spite of his illness, FINSEN had occupied himself greatly with this difficult task. It weighed heavily on his mind that the patients should come under good, healthy, and in all other respects secure conditions so long as they had to remain in Copenhagen.

But here, he from the first encountered unsuspected difficulties. It appeared that the fear of infection was so great that it was almost impossible to procure lodgings for the patients.

Even in his first report FINSEN dealt thoroughly with this question, writing, amongst other things, as follows:

»This fear of infection has expressed itself in a particularly unpleasant way, almost calling to mind medieval conditions, towards a pension for lupus patients, which with the private support of VILH. JØRGENSEN has been started by a Miss H., one of the patients cured in the Light Institute. This lady, who knows by experience the unhappy condition of the patients, thought that a pension for their exclusive use would be a benefaction for them, and of great psychic importance. But her project was nearly stranded. The landlord of the first appartments she took gave her notice to leave, because the rest of his tenants refused to live under the same roof as these people, and it was impossible for her to procure another flat. Thus there was nothing to do but to try and get a whole house, which she could have to herself. A house was found, but before the contract was signed the tenants of the neighbouring houses which belonged to the same owner had got news of this, and threatened to move if the lease was signed. Quarter-day approached, and as the pension was in danger of being homeless, VILH. JØRGENSEN decided, in order to help the patients, to buy a house where the pension could be installed. The house was bought, but then it was all up, as the inhabitants of the street moved heaven and earth to escape this terrible danger, and to get the purchase cancelled. This they succeeded in doing, as at the same time there appeared a way out which has temporarily settled the matter. A

house which was destined for destruction was successfully leased, and fortunately there were no neighbours within several hundred yards.»

This is the story of only one of the difficulties that FINSEN had to contend with. As will be seen from what goes before, the story repeated itself when it was decided to remove the Institute to Rosenvænget.

From the first FINSEN maintained that the Light Institute, as such, had nothing to do with the patients but attend to their treatment, and that they themselves must look after their maintenance and other affairs.

In this he was not right, and later years also showed that he had been obliged to revise his views on this point.

Towards the end of 1901 FINSEN gave an account of the housing conditions of the patients, from which it appeared that the Danish patients were somewhat fortunately placed, as they had two large pensions at their disposal, one for men and one for women, while a number of them found lodgings with relations and friends.

The placing of foreign patients gave more difficulty, especially after the Institute had been moved to Rosenvænget. There certainly had been a special pension for these, but as the number of foreign applicants was so irregular it could not exist and had to be closed in 1901.

No satisfactory arrangement for foreigners has been successfully established since, and these are just as badly off as when the Institute was founded, as no pension dare receive them out of regard for the other boarders, while the vacancies at the Institute are naturally reserved first and foremost for Danes.

An exception is made in the case of poor lupus patients from Sweden. Even during FINSEN's lifetime the Swedish Government tried to arrange for their treatment and care after the Danish pattern. At quite an early stage a special ward for light-treatment had been established at St. Görans hospital in Stockholm, but the elongated shape of the country rendered it difficult to collect in the Capital the patients from the outlying districts. Therefore the »Kungliga Medicinalstyrelsen» commenced negociations with the Institute as to taking over on behalf of the Swedish Government the treatment of poor lupus patients from the thickly populated South Swedish Municipalities, in such a way that the treatment itself should be paid by the Swedish Gov^{t}., while all expenses of maintenance during the cure, journey backwards and forwards, clothes etc. were to be defrayed by the particular communal relief in question, but under State guarantee.

In this the Institute found a new proof of the great confidence

nourished in Sweden for FINSEN and his work, and in 1904 an agreement was made which was ratified by a Royal Swedish Notification of Nov. 11, 1904, according to which the lupus patients referred to the Institute by the »Kungliga Medicinalstyrelsen» were to be treated on the same terms as the Danish poor patients.

Some time before FINSEN died it was realized that in several respects, amongst others hygienically, the private pensions were unsuitable.

It was difficult to break with the tradition that the Institute was not concerned with the housing conditions of the patients, but as a series of cases of patients contracting lung tuberculosis by infection occurred, it was decided in January 1905 to establish a pension for children and young girls. The villa Rosenvænget's Parallelvej No. 7 was leased and adapted for 28 beds, which were not allowed to be occupied by patients with lung tuberculosis. National association for combating tuberculosis undertook the treatment of these at their sanatoriums.

In the long run, however, this arrangement proved unsuitable, as the Sanatoriums could not treat the patients for their lupus at the same time. What was gained as regards lung tuberculosis was spent on lupus, so that the lives of these patients became a continual peregrination between the Institute and the Sanatorium.

In 1908, therefore, a special tuberculosis hospital was established in the adjoining villa Rosenvængets Parallelvej No. 5. This had Government recognition as such, pursuant to the law of state support for the treatment of tuberculosis. It had 9 vacancies — for 8 women and 1 child —, and had one nurse in attendance.

In 1914 notice was given for the lease of this villa.

It was evident that the right path had now been entered upon. The patients were thriving well, and the demand for vacances in the pension of the Institute was rising, while the patients now reluctantly moved into the private pensions, for which reason it was decided to try and bring as many of the patients as possible under the Institute's own care.

In April 1914 the Institute took over one of the private pensions for men, and placed a married couple in charge.

At the same time the tuberculosis hospital was moved to the ground floor of Parallelvej No. 7, the patients from there being moved to a considerably larger villa, Rosenvængets Hovedvej No. 39, which the Institute leased from the Limited Liability Co. »Hjemmet», i. e. The Home.

This Company deserves special mention, because the making of it is testimony to that understanding of what was most serviceable to the Institute, and to that affection which from the first day, so

to say, inspired the two men who for years were the supporting pillars on which the Institute rested economically. It was already started in December 1898 by HAGEMANN and JØRGENSEN together with 3 other members of the Board, the object being to acquire and work a property in Copenhagen for the use of patients attending FINSEN's Medical Light Institute. The share capital was Kr. 50,000, and with the exception of Kr. 300 the shares were all in the hands of HAGEMANN and JØRGENSEN. The Company at once bought the villa Rosenvængets Hovedvej No. 39, but temporarily let it to private tenants.

In 1914 on the anniversary of their seventieth birthdays, HAGEMANN and JØRGENSEN presented their shares to the Institute as a legacy. In this way the Company still existed formally, and from it, as above mentioned, the Institute leased the villa, and adapted it as a pension for women and children. Finally on January 1, 1919, the Company was dissolved, and the property formally transferred to the Institute, which replaced the shares with mortgage bonds in place of the legacies, and at the same time took over the remaining mortgages in the property to the total value of Kr. 75,000, which also were due to HAGEMANN and JØRGENSEN.

As is evident from what has been last stated, the Institute did not stagnate after FINSEN's death, but one endeavoured to lead the work into those fields in which FINSEN had been so deeply interested, but had not had time or opportunity to work up; and it may be said that this was quite in the FINSEN spirit, as his mind had always been greatly occupied with the care of the patient.

In 1913 two of the doctors at the Institute — REYN and STRANDBERG — travelled to Switzerland where, at Leysin, they saw Dr. ROLLIER's sanatorium for treatment of various forms of tuberculosis with sun- and air-baths. At the Light Institute sun treatment had been gradually abandoned, because in Denmark pure, clear sunlight is so rare that it is impossible to institute a regular treatment on this basis. Their visit to Leysin convinced them, however, that FINSEN was right in his belief in the electric light-bath as a remedy for tuberculosis.

In August 1913 REYN began experimentally to treat surgical tuberculosis with electric carbon-arc-light baths. The experiments succeeded beyond expectation, but as a large number of treated cases was necessary to prove the correctness of the method, and as the Institute lacked premises as well as material, he was obliged in 1915 to propose that a special building should be erected for this purpose.

For this the Institute had no funds whatever, but HAGEMAN and JØRGENSEN here again showed their self-sacrifice and interest in the matter by lending the Institute the necessary sum, and in April 1916 the building was in use.

In this up to 140 patients could be treated daily, and as the condition of many of the patients demanded confinement to bed during treatment, several beds had to be at their disposal. At the same time it was necessary to introduce a more rational nursing system; first one, and later several trained nurses, had to be appointed, which finally ended in the complete hospitalization of the patients with a staff of fully qualified nurses.

As regards the women and children the conditions of space after the moving in 1914 were, if not ideal, at least tolerable, if no wish for any sort of comfort was nourished either by patients or staff.

As regards the men, who were lodged in a villa in Rosenvængets Allé, the lack of space was soon very perceptible, and VILH. JØRGENSEN therefore bought a larger property, Rosenvængets Parallelvej No. 3, and conveyed it to the Institute without any disboursement whatever. Here the male patients were now hospitalized.

On April 26, 1916, HAGEMANN died. From the inception of the Institute, indeed from the first time he spoke with FINSEN, he was the soul of the practical and economic management of the Institute; and even if it was BORUP (Mayor) who in the early years was Chairman of the Board — he died in 1903 — it was HAGEMANN who as Chairman of the business committee, and later as Chairman of the Board, took the initiative in every step of importance. He never became FINSEN's friend in the same intimate manner as JØRGENSEN did, but he loved him as did all who came into connection with him, and he saw quickly and clearly what scope FINSEN's ingenious thought might have, and never failed to support him with his influence and means.

The future of the Institute weighed strongly on HAGEMANN's mind. He foresaw that in view of the direction which its development had taken the Institute would never be able to hold its own economically without assistance, and he wished to consolidate it before his own and JØRGENSENS' death. But he also foresaw that, should the Institute succeed in becoming what FINSEN's ingenuity and the later development of the whole Institute justified it in becoming, stronger support than what he and his friend JØRGENSEN had been able to render would be demanded.

On June 22, 1914, therefore he forwarded to the *Ministry of*

Justice, on behalf of the Board, an application in which he referred to the great value of the Institute to the community, and proposed that the State should take over the Institute on such terms as would preserve its character as far as possible as an independent institution.

The idea found accession with the Governement and Parliament, and the *Ministry of Justice* appointed a committee to investigate the possibility of such a transaction by the Government, and to prepare a plan.

On April 26, 1915, the committee met, and prepared a plan by which the Institute was to remain a self owning institution. Two representatives of the State, chosen by the Ministry of Justice, were to join the Board, and the choice of the other members of the Board and of the higher functionaries of the Institute was to be approved by the Ministry, and finally a budget, together with report and statement of account was to be sent to the Ministry of Justice yearly for approval.

The Ministry of Justice sought and obtained authority to carry out this arrangement under the Budget 1917—18. On July 17, 1917, the representatives of the State were appointed, and with this the Institute entered upon a new phase of its existence.

Thus, HAGEMANN did not live to see his plans regarding the future of the Institute realized, but before his death he got the assurance that this last effort for FINSEN's life-task also would bear fruit, and that the Institute would remain through the ages as a proud and worthy memorial of its origin.

Gradually, as the fine results of the treatment of surgical tuberculosis with electric light-baths became known, patients came in constantly growing numbers, and it became necessary to consider how to dispose of them in a proper manner, and in such a way that the good results were not wasted. It was out of the question that all patients could be received at once, but as the period of waiting gradually rose to at least two years before the patients could be treated, one wanted to do one's utmost for those who asked, and as the wish was greater than the means every empty space, even the corridors, was made use of. This was done out of regard for the unfortunate people who saw in light the only possibility of regaining their health, and who had to see this possibility diminish with every day which prolonged the period of waiting; but it was not hygienic.

In 1917 the Board forwarded to the Ministry of Justice an application for a grant from the Exchequer for the erection of a hospital building. The moment was unfortunate inasmuch as the

rise in prices consequent to the war were just then on the increase. According to the first estimate the building could be erected for ca Kr. 800,000, but as the Ministry wished the plan to be altered it was six months before a fresh estimate could be sent in, and the expense had then risen to Kr. 1,271,000. Then prices rose with such rapidity that when this sum had been granted it proved to be quite insufficient, for which reason a third estimate had to be prepared, which amounted to Kr. 1,750,290.

Finally, on January 10, 1919, the building could be commenced. By this time the most difficult conditions were beginning; it was almost inpossible to procure building material, and what material could be had rose to exorbitant prices. It had been decided to erect the building in the garden which belonged to the former property of the Company »Hjemmet», Rosenvængets Hovedvej No. 39, facing the Strandboulevard. Here, in former days, was the beach which bordered the old »Strandpromenade» towards the east, and when digging the foundation large veins of quicksand were met with, which demanded the making of extensive and unexpected foundations.

On the whole the work of construction demanded great resignation, not only on the part of the Institute which continued to suffer badly from want of space, and was obliged to occupy the existing premises so densely that the work of the staff was greatly impeded, but also from the granting authorities, on whom great demands were made, as prices and wages rose and rose to such an extent that the Institute finally had to petition to have the grant raised to Kr. 2,204,000. Thanks to the clear comprehension of the Government and the Houses of the value of the concern to the community at large, the petition was granted; but with this the expense, without fittings, had reached Kr. 15,000 per bed.

The installation of light-baths in the new building has, as is natural, necessitated an increase in the power of the electric engine of the Institute, and therefore is has been necessary to erect a special engine-house, from which all electric constructions are provided with electricity of an even current with tension of 70 volt. For this alteration and extension, and for fittings, the State originally granted Kr. 634,300, but here also the rise in prices has had effect, so that it has been necessary to raise the grant to Kr. 737,395.

The building which has been erected by G. Tvede, architect, with H. Gad, architect, as manager, and Svend Koch as engineer, has its main frontage to the Strandboulevard, and from this 3 sidewings extend towards the west.

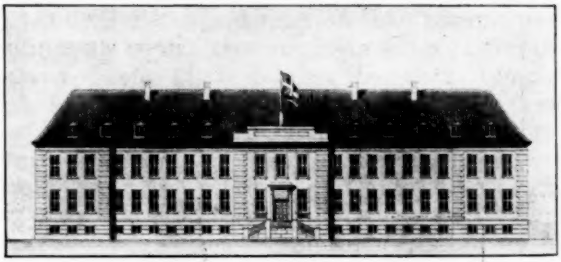

Fig. 1.

The main building and two of the wings consist of cellar, ground floor, first floor, and attics, while the third and centre wing has an open roof terrace instead of the attics.

On the ground floor and first floor are 2 children's wards with 20 beds, 4 wards with 18 beds, and 3 with 5 beds; also isolation wards, 7 with 2 beds, and 4 with 1 bed. Furthermore, 2 living rooms for the patients, 2 operating theatres with anterooms, sterilizing room and plaster-of-paris ward, doctors' rooms, bath-rooms, and pantries. In the cellar are ambulatory, roentgen, and photographic rooms, also light-bath accomodation. In the attic are the kitchen and a number of rooms for the staff. An old villa joined to the hospital building is being adapted as a home for the nurses.

As previously mentioned the Light Institute in its first years was closely connected with the Municipality of Copenhagen, and especially with the Municipal Hospital. In one respect, no doubt, this connection has been of decisive importance to the future of the Institute, as this undoubtedly is the cause of the Institute having its permanent home in Copenhagen.

The great opposition to the lupus patients having intercourse with the inhabitants of the town might easily have led to the Institute, analogously with the asylums for the mentally diseased and for imbeciles, being placed in a remote part of the country. But fortunately for the many other patients who seek the Institute, and not least for the scientific work which is carried out there, this did not happen.

After the connection with the Municipality had ceased with the removal to Rosenvænget, the Institute found support in the State in an ever rising degree, which is all the more natural seeing that the task allotted to the Institute is in reality of the same importance

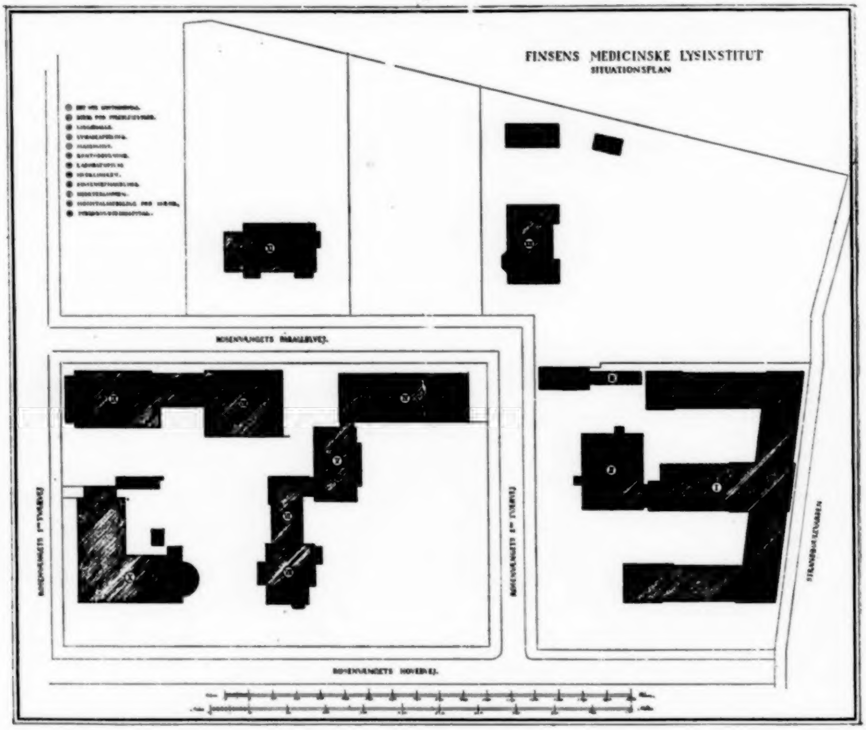

Fig. 2.

for the community as, for example, the treatment of the blind and the mentally diseased.

In the preceding pages an account has been given of the grants and loans rendered by the State. Far the greater part of the grants were for the treatment of patients without means, and although the amount, in proportion to the total expense, may be considered rather small, a small net profit was successfully worked out even so late as 1914. If the State grants have later risen to considerably greater sums, this is due to the economic crisis which supervened with the war.

Besides the grants and loans the State gave its support by laws or administrative decisions which have been of extreme value to the Institute. For example the previously mentioned change in § 61 of the poor-law carried out in 1901, which, further, in 1916

was extended also to comprise patients with surgical tuberculosis. In 1908 the tuberculosis department of the Institute received State recognition pursuant to the law on State support for the treatment of tuberculosis patients, and, finally, in 1921 the newly erected hospital ward for lupus and surgical tuberculosis received State recognition as a coast hospital pursuant to the same law.

But institutions and private people also have rendered assistance to the Institute in various ways, partly for treatment and partly for other and scientific purposes.

In this way the »Classenske Fideicommis», the »Raben-Levetzau Fond», and the »Warburg Legacy» have for many years given their annual contributions for the treatment of patients without means.

After Finsen himself, it is Hägemann and Jørgensen who have made the greatest donations for other purposes, of which the most important have been previously mentioned. In addition to these they have, amongst other things, defrayed the expenses of an expedition to the Tyrolese Alps with the object of studying the respiratory physiological effects of the light and the oxygen. Later they presented the Institute with an expensive pneumatic cabinet for carrying on these studies. But these two men have in so many other ways, and almost on every occasion when the Institute need it, placed themselves at its disposal, both financially and personally, that it is not possible in a short article like this to do them justice. It must suffice to say that without their warm interest in Finsen and the Light Institute the latter would not have advanced as far as it has.

In the course of the years a number of bequests have also been made to the Institute, viz.,

	Kr.
C. Liebe, privy councillor — Bequest	10,000.00
Fyen's diocesan savings bank — Gift	1,000.00
Johan Serdin Hansen, merchant — Bequest	20,000.00
Vilh. Jørgensen, councillor, and wife Anna, née Plenge	100,000.00
G. A. Hagemann and wife — Bequest	24,800.00
Andrea Frederikke Klær, widow née Nielsen — Bequest	2,000.00
Sophie Birgitte Elizabeth Hansen, widow née Schou — Bequest	10,000.00
Peter Haas — merchant — Bequest	9,659.34
Theodor Lund, merchant — Bequest	15,000.00
Pauline Marie Eickhoff, widow née Stock — Bequest	10,752.67
Miss Philippa Jacobine Schiemann Bequest	10,000.00

The unfortunate position of the lupus patients in relation to the rest of the community has been touched on before. It has been

related how the Institute took measures to take in first the young women and children, later the older women and men, although anything but their actual treatment was considered as being beyond its scope. Measures which were continually improved and extended, until now in 1921 a complete hospitalization of all patients who do not seek ambulant treatment is carried out.

But also the spiritual welfare of the patient has been born in mind by the Institute, and in this respect much valuable help has been given, partly from without and partly by the staff of the Institute.

In the spring of 1900 the evening class for women was thus started by the Misses Ussing, Gulstadt, Hoff, Formann, and Rønne, of whom the last four were assistants on the nursing staff of the Institute.

These ladies had themselves collected the necessary sum for procuring the equipment, and themselves gave instruction in Danish, writing, arithmetic, religion, and sewing. For some years the class was supported by the Municipal Hospital, which in this way gave the patients a good deal of sewing work, by which means they earned a little money at the same time that they received instruction.

When Bispebjerg Hospital was built, the supply of sewing from the Municipal Hospital stopped, but the class continued to exist, though under a somewhat altered form. As an experiment, instruction in embroidery and fine needlework was tried, and the ladies who voluntarily had undertaken the instruction were changed several times. In this way the Misses Ulla Fugl and v. d. Maase with Mrs. Esmann have for a number of years rendered valuable assistance to the class, and attended to the patients with great affection and understanding.

In the autumn of 1900, Messrs. Balle and Hoff from the Students' Home started the evening class for men. They began by instructing in the different elementary school subjects, but on account of the very different stages in age and amount of knowledge, it proved difficult to keep up the interest of the class. It was decided to change the instruction, and to proceed to the form of lectures. As this form of instruction made greater demands on the teacher, the work is now performed exclusively by paid instructors. To assist the lecturer a limelight apparatus given by Vilh. Jørgensen is often used.

In 1904 the school for domestic industry was started by the late A. L. Andersen, sergeant-major, and during a number of years the Institute received for this contributions from the Danish Domestic Industry Society. The school has been of great benefit in occupying the male patients during their unoccupied hours, and it is to be

deeply regretted that of late years it has been impossible to procure premises for this tuition.

At the Institute there are always a number of children of school-age from all parts of the country, and in order to preserve during their long stay in the Institute their formerly acquired knowledge, and to prepare children of first school-age to enter school after recovery, a school for children was also started in 1904. The female staff of the Institute undertook this tuition also, to begin with; but as with the evening class for men, the more rational arrangement of appointing a paid teacher was soon adopted.

Since 1912 the Institute has received from the *Ministry for Education* an annual grant of Kr. 1,000 for scholastic purposes.

From an insignificant and very modest beginning Finsen's Medical Light Institute has during the last 25 years undergone a development which may be said to be unique.

FINSEN's ingenious thought of the curing ability of light has proved to possess a vitality and vigour which may be best illustrated by a few figures.

Whereas the start was made on borrowed ground, in a small wooden barrack, the building of which had cost the insignificant sum of Kr. 4,000, the various departments of the Institute now cover an area of 240,000 square feet, of which 172,000 belong to the Institute, and with the buildings thereon have a total value of about Kr. 3,500,000.

The growth of the staff also illustrates the great progress, as we know that FINSEN began with 3 assistants, i. e., a doctor, a lady to assist with the treatment, and a charwoman, whereas the staff now comprises 267 persons.

Many of those who followed FINSEN in his first and most difficult years, when it was a question of rousing belief and confidence in light, have passed away; and many more new people have come forward. But the memory of the ingenious investigator, the eminent physician, the devoted man still lives; not only at the Light Institute but also amongst the thousands who owe him thanks because he gave them back their life.

In the Light Institute NIELS RYBERG FINSEN has set up the most glorious monument imaginable, a work which all Danes will unite in supporting and preserving for the benefit of the afflicted and to the honour of the famous son of the nation.

SUMMARY

In 1894 NIELS FINSEN published his first observation of the fact that he had been able to prevent the development of bad-looking scars in the skin of patients suffering from small pox, — which is otherwise an inevitable result of that disease, — simply by exclusion of the chemical rays of the light from the patients.

In 1895 he started his fundamental researches on the therapeutic effect of concentrated light upon lupus vulgaris. The excellent result of these attracted the keen interest of a number of prominent business men and doctors and inspired them to offer him to establish and support a provisional laboratory for further researches.

In 1896 this resulted in the foundation of a permanent Institute for light-treatment under the name of »*Finsens medicinske Lysinstitut*». The first permanent Institute was built inside the area of the Municipal Hospital of Copenhagen (Kommunehospitalet).

Under these circumstances FINSEN was free to concentrate all his energy on the study of the treatment of lupus vulgaris by concentrated light, applied directly upon the patches.

The result obtained by this treatment attracted the attention of many medical authorities in foreign countries. Hereby it became necessary to organize a regular manufacture and export of instrument for local light-treatment after FINSEN's method.

In 1901 a new large institute was builded in Rosenvænget to meet the still increasing need of room for the rapidly increasing number of patients.

At the same time FINSEN was taking the preliminary steps to start a new serie of researches on the effect of general light-baths upon a number of other diseases.

But FINSEN's state of health had always been extremely delicate, and it was only shortly before his death ($^{24}/_{9}$, 1904) that he laid down in a detailed proposal his final idea concerning the establishment of a sanatorium for the special study of the effect of the general light-bath upon the human organism and upon its different disorders.

This plan was carried out in 1906, a new clinic for internal diseases being opened that year in the month of May.

In 1913 REYN started a series of researches on the treatment of surgical tuberculosis and of lupus vulgaris by general carbon-arc-lightbaths.

The experiments were absolutely successful. In order to ascertain this fact through a sufficient number of experiments a special clinic for this treatment was built in 1916.

In November 1921 a large new hospital for patients suffering from cutaneous or surgical tuberculosis was opened.

ZUSAMMENFASSUNG

Im Jahre 1894 publizierte NIELS FINSEN seine erste Beobachtung des Faktums, dass er imstande gewesen, die Entwicklung der entstellenden Hautnarben bei Blatternpatienten — sonst eine unvermeidliche Folge dieser Er-

krankung — zu verhindern, einfach dadurch, dass er die Patienten vor der Einwirkung der chemischen Strahlen des Lichtes schützte.

Im Jahre 1895 begann er seine grundlegenden Untersuchungen über die therapeutische Wirkung konzentrierten Lichts auf den Lupus vulgaris. Die ausgezeichneten Resultate derselben erweckten das lebhafte Interesse einer Anzahl hervorragender Geschäftsleute und Ärzte und bewogen sie dazu, ihm die Errichtung und Erhaltung eines provisorischen Laboratoriums für weitere Versuche anzubieten.

Im Jahre 1896 führte dies zur Gründung eines permanenten Institutes für Lichtbehandlung unter dem Namen »*Finsens medicinske Lysinstitut*«. Das erste permanente Institut wurde innerhalb der Grenzmarken des grossen städtischen Spitals in Kopenhagen (Kommunehospitalet) erbaut.

Unter diesen Umständen war es FINSEN möglich, dem Studium der Behandlung der Lupus vulgaris durch direkt auf die erkrankte Stelle appliziertes konzentriertes Licht seine ganze Energie zu widmen.

Das Resultat, das durch diese Behandlung erreicht wurde, erregte die Aufmerksamkeit vieler medizinischer Autoritäten in Auslande. Dadurch wurde es notwendig, eine regelmässige Fabrikation und Ausfuhr von Instrumenten zur lokalen Lichtbehandlung nach FINSENS Methode zu organisieren.

Im Jahre 1901 wurde ein neues grosses Institut in Rosenvaenget gebaut, um dem stetig zunehmenden Bedarf an Platz für die rapid anwachsende Zahl von Patienten zu genügen.

Gleichzeitig machte FINSEN die vorbereitenden Schritte um eine neue Serie von Untersuchungen über die Wirkung allgemeiner Lichtbäder auf eine Anzahl anderer Erkrankungen zu beginnen.

Aber FINSEN's Gesundheitszustand war immer äusserst schwach gewesen und es war kurz vor seinem Tode (24/9 1904), als er in einem detaillierten Vorschlag seine endgültigen Ideen betreffs der Errichtung eines Sanatoriums für das specielle Studium der Wirkung des allgemeinen Lichtbades auf den menschlichen Organismus und auf verschiedene seiner krankhaften Störungen präzisierte.

Dieser Plan kam im Jahre 1906 zur Ausführing, indem im Mai dieses Jahres eine neue grosse Klinik für innere Erkrankungen eröffnet wurde.

Im Jahre 1913 begann REYN eine Reihe von Untersuchungen über die Behandlung von chirurgischer Tuberkulose und von Lupus vulgaris durch allgemeine Kohlenbogen-Lichtbäder.

Die Experimente waren durchaus erfolgreich. Um diese Tatsache in einer genügenden Zahl von Versuchen festzustellen, wurde im Jahre 1916 eine Spezialklinik für diese Behandlungsmethode erbaut.

Im November 1921 wurde ein neues grosses Krankenhaus für Patienten mit Haut- und chirurgischer Tuberkulose eröffnet.

RÉSUMÉ

En 1894, Finsen publia sa première observation du fait qu'il avait réussi d'empêcher la formation de cicatrices cutanées déformantes chez les malades atteints de la variole — autrement inévitables à la suite de cette maladie — simplement en interceptant les rayons chimiques de la lumière dans la chambre des malades.

En 1895, il commençait ses recherches fondamentales sur l'effet thérapeutique de la lumière concentrée sur le lupus vulgaire. Les excellents résultats

obtenus éveillaient le vif intérêt d'un nombre d'hommes d'affaires et de médecins qui lui offrirent de créer et de défrayer un laboratoire provisoire en vue de nouvelles recherches.

En 1896, ceci aboutit à la création d'un institut permanent photothérapique sous le nom de »*Finsens medicinske Lysinstitut*«. La premier Institut permanent était construit sur le terrain d'un grand hôpital à Copenhauge (Kommunehospitalet).

Dans ces circonstances Finsen était libre de consacrer toute son énergie à l'étude du traitement du lupus vulgaire par la lumière concentrée appliquée directement sur les plaques.

Les résultats obtenus par ce traitement attiraient l'attention de beaucoup de médecins éminents à l'étranger. Il devenait alors nécessaire d'organiser la fabrication et l'exportation d'instruments pour le traitement à la lumière concentrée d'après la méthode de Finsen.

En 1901, le nombre des malades allant rapidement en augmentant, un grand Institut nouveau fut construit dans le Rosenvaenget.

A la même époque, Finsen commençait à preparer une nouvelle série de recherches au sujet de l'effet du bain total de lumière, sur d'autres maladies.

Mais la santé de Finsen avait toujours étés très delicate et ce n'était que pue de temps avant sa mort (le 24 Septembre 1904) que, dans un projet détaillé, il émettait sa dernière idée de créer un sanatorium spécialement pour l'étude de l'effet du bain total de lumière sur l'organisme humain et sur ses différentes maladies.

Ce projet fut réalisé en 1906, et une grande clinique nouvelle pour les maladies internes fut ouverte au mois de mai de cette année.

En 1913, Reyn commençait une série de recherches sur le traitement de la tuberculose chirurgicale et du lupus vulgaire par les bains totaux à arc de charbon. Les résultats furent très heureux. Afin de confirmer ces resultats, par une série d'expériences suffisamment nombreuses, une clinique spéciale pour ce traitement fut construite en 1916.

En Novembre 1921 un grand Hôpital nouveau pour les malades atteints de tuberculose cutanée et chirurgicale fut inauguré.

REPORT FROM THE SURGICAL WARD C OF THE RIGSHOSPITAL, COPENHAGEN — HEAD SURGEON, PROF. THORKILD ROVSING, AND THE RÖNTGEN CLINIC OF THE RIGSHOSPITAL — CHIEF, DR. PANNER

RÖNTGEN TREATMENT OF PRIMARY POLYGLOBULY

by

Frode Rydgaard

Amongst the very large number of problems with which radiology is concerned, the effect of Röntgen Rays on normal and pathological blood occupies a prominent position.

While, in some respects, it must be considered doubtful, whether the therapeutic problem of the diseases of the blood can be solved by Ray treatment, yet coinciding observations seem to give very bright prospects for a Röntgen treatment of polyglobuly.

Polyglobuly has been divided, rightly or wrongly, into primary and secondary forms, and by primary polyglobuly must be understood that form which cannot be referred to any other disease. Included in primary polyglobuly we recognize different groups, such as *Polyglobulia megalosplenica Vaquez* and *Polyglobulia hypertonica Geisböck*. It is difficult to imagine that these different groups have the same etiology, that, in other words, primary polyglobuly should form a disease entity, but as the different forms seem to react in the same manner under treatment, one may for the present be justified therapeutically to discuss them as one.

The methods of treatment employed with primary polyglobuly fall into three groups, viz., medical, surgical, and radiological methods.

The medical treatment has, on the whole, been only symptomatic, thus with food free from iron, with arsenic, with benzol and other medicaments; inhalation of oxygen, venesection, lumbar puncture, etc. I shall not enter further into the importance of these remedies. At present it is generally agreed that none of them is perfect, but that in special cases some of them are very adaptable symptomatic methods of treatment.

The surgical treatment has consisted of splenectomy. In a previous article I have collected five reports on splenectomy from the literature. It cannot be determined whether the removal of the spleen affects the polyglobuly. The cases observed by COMINOTTI and

SCHNEIDER point, if anywhere, towards a favourable effect, but COMINOTTI's patient was observed for too short a period, and the case of SCHNEIDER's patient is too complicated to enable one to draw definite conclusions. It is certain, however, that the operation is so risky that we, with ROVSING, must consider splenectomy as counter-indicated with polyglobuly.

Röntgen treatment with polyglobuly was tried much earlier: but not until later years with success. As with every other Röntgen treatment, it is difficult to compare the various dosages and their results. As regards the method of application the Röntgen treatment of a patient with polyglobuly may be divided into three groups, viz.

(1) Röntgen treatment of the spleen alone.

(2) Röntgen treatment of bone-marrow alone.

(3) Röntgen treatment of bone-marrow and spleen.

As will be seen from the following, I think one is able, so far as can be judged from observations made during 1—3 years, to cure polyglobuly with Röntgen treatment, but in order further to distinguish which of the 3 methods of application is the sovereign one, and in order to get an estimate of the effective dosages, I have gone through the observations reported in the literature. I have been fortunate enough to be able to add 3 of my own observations (Obs. I, II, and III), which have been cured, one with Röntgen treatment of the spleen, and two with treatment of spleen and bone-marrow.

RÖNTGEN TREATMENT OF THE SPLEEN

As early as 1904 VAQUEZ mentions that Röntgen irradiation of splenic tumour with polyglobulia megalosplenica had been attempted, but does not report having seen any effect. In GEISBÖCK's classical publication of 1905 mention is made of one of the patients having been Röntgen irradiated on the spleen without result. Similar reports are to be found during the following years, so that PANCOAST, in a survey of 1908, could with some justice pronounce that Röntgen treatment of polyglobuly had not given encouraging results. In spite of this there were several authors who continued the experiments with the spleen treatment, and when in March 1919, at Ward *C* of the Rigshospital, a patient was admitted who presented the characteristic symptoms of Polyglobulia megalosplenica Vaquez, a Röntgen treatment of the patient's enormously enlarged spleen was begun. By this treatment the patient was cured, and she is enjoying good health today. In the following I have reported the journal of this patient (Obs. I), and have then collected from the literature the observations pertaining to this.

Own Observation I.

J. H. L. 37 years. Divorced. Admitted 15/3 1919 with the diagnosis Icterus, Colitis, Peritonitis localis. Discharged 9/5 1919. The patient's father and one sister died of Tub. pulm. The sister who died at the age of 47 had jaundice when younger. For the rest no morbid disposition and no occurrence of jaundice in the family. The patient enjoyed good health till the present illness began. The patient has never been gravid. Menses were always regular previously, but during the last six months they have become scarce, and very irregular.

About 12 months ago the patient — without knowing any cause for it — suddenly noticed cold and insensibility in the r. lower extremity, from the toes almost up to her knee. All this portion became pallid. The cold, pallidity, and insensibility of the leg lasted several weeks. Transitory blue spots are said to have appeared on her foot, but the patient has never at any time felt pain in the part afflicted. She was treated with various unguents, and the attacks gradually vanished, and have not reappeared since.

Since then, however, the patient has not felt well, having suffered from increasing fatigue, headache, nervousness, and a rush of blood to her head. She has further suffered from constant diarrhea. She has had no periods of constipation and has not observed melena. Lately she has suffered a good deal from nausea, but otherwise has had no dyspeptic attacks.

In addition to the symptoms stated, a severe attack of pain occurred in the left side of the abdomen 3 months ago. The pains appeared suddenly in the night, lasted several hours, and had the character of colic. Since this attack she has constantly suffered from oppressive, dull pains under the left curvature, and from time to time momentary pricking pains, as if she were »tearing off a scar». During the last month the patient has had two attacks of colic of the same character as the first. After the last attack — 10 days before admittance — the doctor diagnosticated icterus. This jaundice, however, had not been noticed by those about her, and faeces had not been acholic. The patient has had no symptoms from the thoracic organs; no symptoms from the urinary tracts. During her illness she has fallen off greatly, and during the last month has been quite incapable of work.

Obj. examination: Patient is weak. One notices at once that her complexion is flushed, bordering on cyanotic. Otherwise no redness of the skin. No peripheral swelling of the glands worth mentioning.

Steth. pulm. natural. Steth. cordis: boundaries natural. Tone true. $A_{II} = P_{II}$.

Abdomen rather large, especially its upper left part.

Umbilical circumf. 64 cm. Veins slightly prominent. On palpation a tumour is felt protruding below the middle of the left curvature, reaching as far as the centre line, and swinging down to the umbilical transversalis, and from here out into the left lumbar region. It is solid, hard, and shifts slightly in respiration. Inward and towards the front it has a solid, plump edge, of slightly irregular shape. Another edge of it protrudes distinctly in the lumbar region, rebounding on pressure. The percussion tone over tumour is dulled: dulness of the liver from C VI to the curvature: edge of liver not felt: no sign of ascites.

Extremities normal. Reflexes normal.

Nothing abnormal on Exploratio recto-vaginalis. There is a slight yellowish tinge of sclerae, no icterus of the skin.

Urine: Albumen 0, saccharum 0. Microscopy of sterile urin showed: no abnormal constituents, but numerous urates. Urin: Urobilin + (1:10), bile colouring matter 0. Blood pressure 165 mm.

Ewald (3/4 hour). Quantity 17 + 37. Congo 5, phenolphthalein 15.

Bourget (8 hours). Retention 0.

Pirquet's reaction: weakly positive. Wassermann's reaction negative.

Discharge: Blood 0, mucus 0.

Blood examination: osmotic resistance; test: incipient hemolysis 0.46 %. Total hemolysis 0.32 %.

Hemoglobin: 112 % (Sahli[1]).

Erythrocytes 7,830,000. Dry preparation: no normoblast, no megaloblasts. Only slight poikilocythosis.

Leucocytes: 3,500. Polynuclear cells ca. 67 %. Lymphocytes 20 %.

Various large cells, some with round, some with shrivelled nuclei ca. 13 %.

Weight 43 kilo.

22/3. Röntgen treatment of spleen instituted.

On account of the size of the splenic tumour it was at first necessary to treat it as two areas; later the tumour diminished so much that the treatment could be performed over the whole area.

Date	Area Site of Treatment		Dose	Filter
22/3 1919	Spleen	Area 1	5 H.	5 mm. Al.
24/3 »	»	» 2	»	»
26/3 »	»	» 1	»	»
28/3 »	»	» 2	»	»
31/3 »	»	» 1	»	»
5/4 »	»	» 2	»	»
7/4 »	»	» 1	»	»
9/4 »	»	» 2	»	»
18/6 »	Spleen		»	»
23/6 »	»		»	»
27/6 »	»		»	»
1/7 »	»		»	»
6/11 »	Spleen		10 H.	»
30/1 1920	Spleen		10 H.	»

The course of the illness after treatment was as follows:

16/4 1919. Splenic tumour very considerably diminished. Now it does not extend further than two fingerbreadths from the median line and two fingerbreadths above the umbilical transversalis.

Sahli 115 %. Red corpuscles 7,020,000.

5/5. Subjectively patient is better, as the rush of blood to her head does not

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[1] This and the following hemoglobin determinations after Sahli are a little to low (5—10 %). The later examinations have been performed with Autenrieth-Königsberg's hemoglobinometer, which Dr. H. B. Gram kindly corrected for me. Hereby it was ascertained that my Sahli hemoglobinometer gave too low figures when the hemoglobin percentage was above 100.

occur so frequently as before, and the colour of her face also is less pronounced. Still complains of pains in the region of the spleen. Weight 48 Kilo (increase in weight 5 Kilo).

Sahli 115 %. Red corpuscles 6,960,000.

$^{9}/_{5}$. Discharged.

$^{11}/_{6}$. Feels perfectly well. Skin natural. Spleen further diminished.

Sahli 110 %. Red corpuscles 5,860,000.

$^{16}/_{7}$. Still improving. Still some fatigue and nausea. Spleen extends two fingerbreadths below curvature.

$^{6}/_{9}$ Sahli 102 %. Red corpuscles 5,230,000.

$^{25}/_{9}$. Remarkably well. At times patient notices slight pricking in region of spleen, but is otherwise entirely free from pain. Her headache, fatigue, and weakness have entirely disappeared. Discharge quite normal. Menses regular.

The colour of the patient's skin is normal, and the edge of the spleen is felt just 2 cm. below the curvature. Patient is quite capable of doing her work as umbrella maker.

Sahli 107 %. Red corpuscles 5,860,000.

$^{6}/_{11}$. Sahli 98 %. Red corpuscles 4,950,000.

$^{11}/_{11}$. Hemoglobin 101 % (A-K.). Red corp. 4,730,000.

$^{22}/_{11}$. Hemoglobin 101 % (A-K.). Red corp. 5,020,000.

$^{28}/_{1}$ 1920. Perfectly well. During deep inspiration the spleen is felt a couple of fingerbreadths below the curvature. During expiration it can just be palpated.

Hemoglobin 92 % (A-K.). Red corpuscles 5,140,000.

$^{15}/_{5}$. Hemoglobin 92 % (A-K.). Red corpuscles 5,070,000.

During the autumn of 1920 and the beginning of 1921 the patient was away.

At the examination, $^{13}/_{3}$ 1921, the following conditions were found:

Patient states that she is quite capable of doing her work. She has no headache, feels no fatigue, has no pains or sensations in the region of the spleen. Her nervousness is also improved, but she is easily agitated, and she says that when she gets very excited she can feel the blood rising to her head. Discharge daily and normal. Menses regular and normal.

Patient's appearance quite normal. Complexion pale. No flush or cyanosis of ear-lobe or hands. Spleen cannot be felt below the curvature. Only when the patient respires does one seem to feel the edge of the spleen up under the curvature. The dullness of the spleen does not seem extended. The rest of the examination shows normal conditions.

Blood pressure: 155 mm. Red corpuscles 4.76 Mill. White corpuscles 4,800.

Hemoglobin (A.-K.) 94 %.

Dry preparation: No r. corpuscles. No normoblasts. Diff.-counting of white corpuscles shows normal conditions.

$^{25}/_{11}$ 1921. Condition as 8 months ago.

Hemoglobin (A-K.) 100 %. R. corpuscles 4.68 Mill.

$^{14}/_{7}$ 1922. $2^{1}/_{2}$ years after last treatment, is now employed in a shop. Fully capable of working. No pains or other symptoms.

Patient's appearance normal. No erythrocytosis.

Abdomen normal. Only during inspiration can edge of the spleen be felt.

Hemoglobin (A-K.) 95 %. Red corpuscles 5 010,000.

White corpuscles 5,900. Blood aspect normal.

Epicrisis. As the journal shows, the patient suffered from polyglobulia megalosplenica Vaquez. She essentially presented the complex of symptoms which BIE, in his well known review characterises as cerebral symptoms, dyspeptic symptoms, and splenic pains; and this together with her whole *habitus*, the splenic tumour and the examination of her blood, justifies the diagnosis.

When admitted the patient was extremely exhausted, with serious symptoms, and greatly swollen spleen. She had been ailing for at least 12 months and became worse and worse to the moment when the Röntgen treatment was begun.

This consisted of a vigorous treatment of the spleen. In the course of 7 months the patient had 80 H through 5 mm. Al.-filter.

The patient has been observed for $2^1/_2$ years since the last treatment. She is completely freed from her symptoms, and has a normal number of red corpuscles. The enormous swelling of the spleen has so far diminished that one can feel only the edge of the spleen up under the curvature.

Own Observation II. (See page 251.)

Besides Röntgen treatment of the blood, the patient had treatment on the spleen, in all from $^{29}/_{11}$ 1919—$^{1}/_{11}$ 1920; 40 H + 4 Sabouraud through 5 mm. Al. Subjectively there was a temporary improvement, and the pains in the spleen disappeared, but the aspect of the blood was only temporarily changed.

Own Observation III. (See page 254.)

The patient had Röntgen irradiation of the spleen from $^{14}/_{7}$ 1920—$^{7}/_{1}$ 1921, in all 8 Sab. After which, temporary fall in the number of red corpuscles and temporary subjective improvement.

Cases from the literature.

VAQUEZ (1904) and GEISBÖCK (1905) saw, as stated above, no effect of Röntgen treatment.

ALDRICK and LE ROY CRUMMER (1907) treated a patient who had $7{,}7$ mill. erythrocytes, hemoglobin 120 %, and a splenic tumour to spina. A month after the Röntgen treatment the spleen has diminished considerably; the number of erythrocytes is 6,048 mill.; Hgbl, 90 %. After an attack of jaundice some months later the patient had a temporary enlargement of the spleen, but had continual good health.

BÖTTNER (1909) reports two cases.

Case I (Typus Vaquez) got 29 irradiations (13 of 10 minutes, 16 of 12 minutes, stannum filtration, distance of skin focus 12—15 cm.) without effect on spleen and aspect of blood.

Case II (Typus Vaquez) had 15 minutes irradiation daily for about 1½ months. Hereby the swelling of the spleen disappeared. The number of erythrocytes fell from 7.9—5.68 mill. Hmglb. from 120 % to 100 %.

HÖRDER (1911) treated one patient with 9 seances of Röntgen irradiation of ½ hour each. The irradiation had no essential result.

KUTTNER (1912) reports having treated one patient with polyglob. Vaquez with irradiation of the spleen without essential or permanent result. Dosage not reported.

PICK (1913), in a treatise on a patient who had 9 mill. r. corpuscles and splenic tumour, reports that the number of red corpuscles after one irradiation of the spleen (dosage not stated) fell to 8 mill., only to rise again soon.

MOEVES (1913) had treated a patient who had Polyglobulia Vaques with 8 irradiations of the spleen. The splenic tumour diminished herewith, but no permanent improvement followed, and there was only a slight and tempory fall in the number of erythrocytes.

PAGNIEZ, LE SOURD, and BEAUJARD (1913) report a case where — after treatment of the spleen — the enormous swelling of the spleen decreased to half its size, the number of erythrocytes fell from 6,3—5,7 mill. (lowest 4,97), followed by subjective good health.

GSTREIN and SINGER (1918) have observed temporary decrease of splenic tumour after Röntgen irradiation (dosage not stated).

STRAUSS (1920) reports never to have observed effects from treatment of the spleen, but reports no case.

RÖNTGEN IRRADIATION OF BONE MARROW

On the basis of the well-known fact that the bone marrow is hyperplastic in patients suffering from polyglobuly, one has tried at a fairly early date to treat the bones with Röntgen rays. Only a few bones were treated, however, and the treatment was not particularly intensive. Some authors (PARKINSON, for instance) observed temporary results; others saw no effect.

In 1917, however, TANCRÉ reports a case where bone irradiation has given a surprising result, and since then quite a series of similar observations has been forthcoming in the literature.

TANCRÉ (1917), 32 years old woman.

R. corp. 14.2 mill., hemoglob. 178 % (Sahli). No splenic tumour

Blood pressure 110. Röntgen treatment of long tubular bones, sternum and claviculæ: altogether 21 dosages of strong rays. After last treatment the erythrocytes were 10.3 mill., and hmglb. 172 %. Subjectively, considerable improvement. 3 weeks later: erythrocytes 6.6 mill., hglb. 163 %.

Lüdin (1918). 27 year old woman. R. corpsc. 7.3 mill., hmglb. 145 %. No splenic tumour. All the bones treated in the course of 7 weeks with 94 full dosages according to Sabouraud. After first treatment with 30 Sabouraud, erythrocytes were 6.5 mill., hmglb. 119 %. 5 months after last irradiation erythrocytes were 4.88 mill., and hmglb. 100 %; and $2^1/_2$ years later erythrocytes 5.02 mill. and hmglb. 100 %.

Guggenheimer (1919). 29 year old woman. Erythrocytes 8.4 mill., hmglb. 140 %.

Irradiation of the short flat bones with dosages as in energetic gynecological deep treatment. (Zink filter, irradiation of 4 areas daily, during 3 weeks.) The hemoglobin fell from 130 % to 80 %; erythrocytes from 7.1 to 3.8 mill. The patient became extremely exhausted, and picked up only slowly. About 6 months after treatment the aspect of the blood was normal, and the patient perfectly well.

Forschbach (1919). 61 year old man. Ill during 4 years. Number of r. corpuscles between 7 and 12.5 mill., hmglb. 100 à 150 %. In 1916 the patient had 27 bone irradiations (extremity bones) of 10x through 3—4 mm. Al. without any effect. 12 months later treatment was again begun and from $^{15}/_{9}$ 17—$^{27}/_{5}$ 18 the patient received 7 series of treatment, each of 16 separate treatments of 10x. Only after the sixth of these did the number of erythrocytes begin to fall, and became subnormal (3.3 mill.) during the following months — without fresh treatment. About 12 month after last treatment hmglb. is 90 %; r. corps. 4.79 mill. The patient's complexion became normal. The swelling of the spleen smaller. Subjective good health.

Lüdin (1920). 45 year old woman. R. corpsc. 6.5 mill., hmglb. 105 %. Treatment of all the bones with 48 full doses according to Sabouraud-Noiré. After the treatment erythrocytes 4.7 mill., hmgbl. 88 %.

Lüdin. Patient with hmgbl. 140 %, erythrocytes 8.8 mill. Treatment from $^{11}/_{3}$ 1919—$^{22}/_{5}$ 1919 of all the bones with altogether 142 Sab. under 4 mm. Al. Condition of blood after treatment 4.8 mill. erythrocytes, and 73 % hmglb. Subjectively, considerable improvement.

STRAUSS (1920) reports having obtained excellent results from irradiation.

THAYSEN (1920). 54 year old woman. Number of erythrocytes varying from 5.08 to 11.8 mill. 3 treatments each of 8—12 Sab. given on the bones. Temporary improvement after the first treatments, no improvement after the last.

RÖNTGEN TREATMENT OF SPLEEN AND BONE MARROW

As one succeeds in some cases in obtaining results by Röntgen irradiation of the spleen, and in others by irradiation of the bones, as appears from the above, it seems only rational to combine these methods of treatment.

The first attempt at this was made by PARKINSON in 1908, but otherwise the only reports to hand regarding this are dating from the last 3 years.

In two of my own observations this treatment has been successfully carried out. These observations are reported first, and then those published in the literature.

Own Observation II.

K. K. 45 year old married woman. Ward *C.* $^{2}/_{10}$ 1919—$^{2}/_{11}$ 1919 and $^{12}/_{3}$ 1921—$^{19}/_{4}$ 1921. Patient's husband and 8 children are all healthy. She herself was healthy in childhood and youth. Menses regular until the last year; now scanty and somewhat irregular.

During the last 12 months she has felt fatigue, but otherwise has been well until a month ago when she began to feel pains in the abdomen, mostly in left hypochondrium. The pains were independent of the meals, and did not cease when the patient lay down. No dyspepsia; slight constipation.

The examination shows striking cyanosis of the face with much phlebectasis. She thinks this has only developed during the last year.

Steth. cordis et pulm.: natural. The spleen is felt protruding a couple of fingerbreadths below the curvature, but left kidney cannot be felt, though the right can, lying low down.

Rest of objective examination shows nothing abnormal.

Urine normal.

EWALD's test-meal: quantity 30 + 35. Congo 55. Phenolphtalein 91. BOURGET's test-meal: no retention. Blood pressure 110. Blood count ($^{3}/_{10}$ 1919) 118 % (SAHLI). R. corpsc. 8.38 mill. Wh. corpsc. 9,900. Diff. counting: Polynuclear neutrophile 82.8 %, eosinophile 3.1 %. Lympocytes 10 %. Transition forms 4.9 %. $^{24}/_{10}$ 1919, hemoglobin 128 % (AUTENRIETH-KÖNIGSBERG). R. corps. 7.20 mill. (Blood examination: Dr. H. C. GRAM.)

Röntgen treatment of spleen, liver, and large vessels, with the object of treating the blood, is begun.

Hemoglobin determination acc. to SAHLI is too low. See footnote page. 246.

The following treatment was given.

Date	Area of Treatment	Dose	Filter
21/10 1919	Thorax	10 H.	5 mm. Al.
27/10 »	»	»	»
10/11 »	»	»	»
13/11 »	»	»	»
29/11 »	Spleen	»	»
7/1 1920	»	»	»
24/1 »	Liver	»	»
11/2 »	Spleen	»	»
21/3 »	»	»	»
22/5 »	Liver	2 Sab.	»
25/5 »	Spleen	»	»
28/8 »	Liver from side	»	»
31/8 »	» » front	1 Sab.	»
3/9 »	» » »	»	»
30/10 »	Spleen	»	»
1/11 »	»	»	»
3/11 »	Liver from front	»	»
5/11 »	» » »	»	»
8/11 »	» » side	»	»
10/11 »	» » »	»	»

The result of this treatment was that, subjectively, the patient's health improved, and, in particular, the pains in the spleen ceased, but continuously there was rather pronounced erythrocytosis, and the blood examination showed the following:

Date	Hemoglobin (Aut.-K.)	R. Corpuscles
29/11 1919	110 %	6.66 mill.
6/12 »	106 %	5.54 »
17/12 »	108 %	5.64 »
23/1 1920	105 %	6.42 »
15/6 »	120 %	
29/11 »	116 %	
14/3 1921	119 %	7.04 »
		(Wh. corpsc. 19,200.)

In the middle of February 1921 the patient caught cold, with temperature and cough, and again suffered pains in the epigastrium and the region of the spleen. The pains were independent of her meals. At the same time the patient noticed melena, and on 12/3 1921 there was hematemesis of about 1/2 litre. For which reason she was admitted to the ward on the same day.

The examination proved nothing beyond what was previously found. There was no hematemesis after admittance, but melena which was maintained for a fortnight.

The diagnosis polyglobuly with bleeding of varices was established, and it was decided to begin a vigorous Röntgen treatment of the long tubular bones.

The following dosages were given:

Date	Area of Treatment	Dose	Filter
From 6/4—14/4 1921 . .	Femora, crura humeri et antebrachii	In all 16 Sab. (Each dose 2 Sab.)	5 mm Al.
» 23/5— 2/6 » . .	do.	In all 20 Sab. (Each dose 2 Sab.)	do.
» 4/7—14/7 » . .	do.	In all 27 Sab. (Each dose 3 Sab.)	do.
» 12/9—17/9 » . .	Femora et crura	In all 12 Sab. (Each dose 2 Sab.)	do.

After this treatment of 75 Sab. in all, a decided turn in the illness set in.

Even on 2/5 1921 — after the first series of treatment — it is noted in the journal that the patient's face has become distinctly paler, and that her general state of health is excellent.

17/12 1921. A little more capable of work. General condition good. Appearance completely changed.

8/2 1922. Excellent health continued. Attends to her house-work without assistance. Appearance not polycythemic.

Examination of the blood showed the following:

Date	Hemoglobin (Aut.-K.)	R. Corpsc.
26/4 1921	114 %	5.76 mill.
3/5 »	112 %	5.5 »
31/5 »	—	4.91 »
2/7 »	108 %	5.06 »
		(Wh. Corpsc. 9,600)
18/7 »	—	4.96 mill.
21/9 »	92 %	4.1 »
8/10 »	90 %	3.49 »
22/10 »	—	4.37 »
24/11 »	92 %	3.94 »

At the examination on 14/8 1922, about 12 months after last treatment, appearance of patient is found normal. There is no redness of face or ears, and she attends to her house without assistance, and apart from some nervousness she is in every respect quite well. No fatigue, no pains.

Examination of the blood showed: hemoglobin (Aut. K.) 91 %. R. Corpsc. 4,32.

Epicrisis: The patient had primary polyglobuly, if anything *typus Vaques*, but with moderate splenic tumour. Röntgen treatment of the spleen and simultaneous treatment of the blood (the large vessels and the liver) was tried, but without effect. A temporary subjective improvement, and a reduction in the number of red corpuscles were soon followed by a return of all symptoms. Treatment was

then begun of the bone marrow with large Röntgen dosages, and thereby an apparently complete recovery was obtained, which has been maintained to this date, about 12 months after last treatment.

Own Observation III.

J. M. C. 44 year old woman.

In May 1920 the patient had been in Ward *A* of the Rigshospital for polyglobuly. At that time she had suffered from pains in the *l.* side of her abdomen below the curvature for about 6 months. Objectively was found distinct redness of face and fingers. The spleen was felt a couple of fingerbreadths below the curvature. Blood pressure 165 mm. Hmglb. 122 % (Aut.-K.). R. corpsc. 8.15 mill. Leucocytes 18,300. Aspect of blood normal.

During 1920 and the beginning of 1921 the patient received the following treatment.

Date	Area of Treatment	Dose	Filter
$^{1}/_{5}$—$^{10}/_{5}$ 1920	Femora, crura brachii, antibracchii	Each dose 2 Sab. In all 18 Sab.	5 mm. Al.
$^{14}/_{7}$ 1920	Spleen	2 Sab.	—
$^{27}/_{8}$ and $^{31}/_{8}$ 1920 . . .	do.	Each dose 1 Sab.	—
$^{1}/_{11}$ and $^{3}/_{11}$ » . . .	do.	1 Sab.	—
$^{4}/_{4}$ » $^{7}/_{4}$ 1921 . . .	do.	do.	—

This brought about a quite temporary subjective improvement, and a temporary fall in the number of red corpuscles.

In September 1921 the patient was referred to me for examination. She was then pronouncedly erythrocytotic. Face and hands very red and lobes of the ears purple. She felt slack but had no pains.

Hemoglobin 115 (corr. Sahli). R. corpsc. 9.0 mill.

After an agreement with Dr. Panner a vigorous bone irradiation was begun. The following treatment was given.

Date	Area of Treatment	Dose	Filter
$^{12}/_{9}$—$^{26}/_{9}$ 1921	Femora, crura humeri et antibrachii	Each trtmt. of 2 Sab. In all 18 Sab.	5 mm. Al
$^{25}/_{11}$—$^{8}/_{12}$ »	do.	Each trtmt. of 3 Sab. In all 30 Sab.	—
$^{16}/_{3}$—$^{27}/_{3}$ 1922	do.	do.	—

The effect of the first series of 18 Sab. in all was not specially pronounced.

$^{15}/_{11}$ 1921. R. corpsc. 7.6 mill.

After the next series of treatment of 30 Sab. in all her condition improved considerably, and her face got very much paler.

Examination of the blood on $^{25}/_{2}$ 1922 showed hmglb. 98 % (Aut.-K). R. corpsc. 6.02 mill. After the last series of treatment, again 30 Sab., the patient felt very well. She looks after her house, and is in every respect perfectly well.

Examination on $^{15}/_{8}$ 1922, about 6 months after last treatment shows:

Patient's complexion quite pale; general condition good; fully capable of working.

Hmgbl. 98 % (Aut.-K.). R. corpsc. 4.57 mill.

Cases from the Literature.

MÖNCK (1919). 52 year old woman. Hmglb. 170 %. R. corpsc. 7.48 mill. Treatment of pelvis for 140 minutes, of spleen 60 minutes, and of femora 120 minutes. Later two treatments of femora 100 minutes and of spleen 120 minutes, in all. M. states that a dosage of 40 min. with his apparatus is equivalent to a little more than 45x.

6 weeks after last treatment the blood pressure was 130., r. corpsc. 3,8 mill., hmglb. 70 %.

3 months after last treatment improvement still maintained.

BÖTTNER (1920). Patient with 9,88 mill. *r.* corpsc. and hmglb. 145 %. Was first treated during 29 days in 29 areas, each area 60—80x. Afterwards, during 16 days in 16 areas to 80—90x. Eleven of the treatments were administered on the spleen, and the 34 mainly on the long tubular bones.

After the first series no special effect. Immediately after the second series the number of *r.* corpsc. fell to 6.2 mill., six weeks later hmglb. was 90 %, and *r.* corpsc. 4.79, and about 3 months later 4.8 mill., and hmglb. 86 %.

WALTER FÖRSTER (1920). Patient with large splenic tumour and *r.* corpsc. 8.1 mill. Treated on long tubular bones with 3 series, each of 4 dosages, 10—12 Fürstenau each. The spleen was treated with 10—15 Fürstenau. (Spleen previously treated without effect.) Subjective good health ensued, and the number of the r. corpuscles fell to 3.68 mill.

Results of Röntgen Treatment.

On the basis of the material before us, 3 cases observed by me, and the cases from the literature, we must now investigate what results Röntgen treatment of polyglobuly gives.

There is all the more reason to examine this question closely, seeing that hitherto the handbooks and text-books have adopted a rather disapproving attitude towards Röntgen treatment of polyglobuly.

Thus MOSSE writes in »Spec. Pathologie und Therapie d. inn. Krankheiten 1920» that Röntgen treatment of the spleen is quite without effect where polyglobuly is in question, and in »Lærebog i

intern Medicin, 1921» Tallquist only just mentions that Röntgen treatment has been attempted with polyglobuly, while Forssell states that Röntgen treatment can cause a fall in the number of red corpuscles, at any rate temporarily.

First, as regards the treatment of the spleen, the reported results of this vary considerably. In some cases the polyglobuly is visibly influenced. The best example is my observation I. This patient is still well, 2 1/2 years after the treatment. In 3 other cases (Aldrick and Le Roy Crummer, Böttner (case II), and Pagniez, Le Sourd and Beaujard) the treatment also gave favourable results. Altogether four cases belonged to typus Vaquez.

Immediately opposed to these four observations, however, we find a whole series of reports of ineffectual treatment of the spleen, and the question then arises whether the varying results are due to the nature of the disease or to the technic. Here, as everywhere, it is extremely difficult to compare the dosages of the different treatments, but a comparison can be drawn, however, between my observations I and II. The first mentioned patient received treatment of the spleen with 80 H. during 9 months, and the last mentioned 40 H. + 4 Sab. during about 12 months; and while Obs. I attained complete recovery Obs. II was in reality unchanged.

Böttner's patients I and II are also well suited to be compared; the one case is favourably influenced, the other not at all.

The conclusion to be drawn from this is that Röntgen treatment of the spleen acts differently in different cases. In some cases, all of Typus Vaquez, sometimes considerable improvement and sometimes recovery has been attained, and in other cases, indeed most, the patients are not affected by this treatment.

Irradiation of the Bone marrow has been performed partly together with and partly independently of spleen treatment. The old reports on bone treatment were rather disheartening. Since 1917, however, 12 observations in all have been reported, including my two cases published here, and in 11 of these the result has been that the disease has apparently been cured by irradiation of the bone marrow.

The cases before 1917 having been treated with rather small dosages, at least as far as one can see, and the dosage being also rather small in one (Thaysen) of the 12 cases where there was no effect from the treatment, whereas the 11 patients whith a favourable progress were all subjected to intense irradiation, there can hardly be any doubt but that the good results are due to the vigorous irradiation of the bone. In this respect my observation III is also instructive. In 1920 the patient received irradiation of the bone marrow with 18 Sab. in all, without effect, while a treatment with 68 Sab. in 1921 gave a bril-

liant result. It can also be seen from several of the published journals, Forschback and Böttner for instance, that the effect is not noticed until the large dosages are reached. It may be objected to the results obtained that one does not know if the patients are permanently cured. In many cases the time of observation is rather short, but some patients have been under observation, however, for 1—$2\frac{1}{2}$ years, and no case of relapse after intensive treatment has been reported.

The conclusion then must be that, according to the provisional investigations, it looks as if we have got an apparently effective remedy for polyglobuly in intensive irradiation of the bone marrow.

The effect of Röntgen rays must certainly be considered as a specific effect on the blood forming cells in the bone marrow. It has been asserted that merely a simple blood treatment was required, but my observation II contradicts this, as the patient was for a long time treated with Röntgen irradiation of the large blood vessels and the liver without any result, while the treatment of the bone marrow gave good results.

Technic of Röntgen Treatment.

From the above there can be no doubt that every case of polyglobuly ought to be treated with Röntgen rays. It now remains for us to investigate whether any clue can be got from the published observations as to the carrying out of the treatment.

First, *as regards the area of treatment*, this ought above all to be the bone marrow. Some have treated the flat and short bones, others the long tubular bones. To me it seems right to choose only the long tubular bones. Firstly because it is in these that hyperplasia of the marrow is found, and secondly because patients often feel pain in the long tubular bones, which pains often disappear under Röntgen irradiation (Böttner, Forschback).

The bone treatment is given partly with and partly without irradiation of the spleen. In cases where the spleen is not enlarged, treatment of this is scarcely necessary. If, however, there is swelling of the spleen, this should be irradiated, and for two reasons. Firstly because some cases improve with irradiation of the spleen alone, which indicates that the swelling of the spleen plays a certain rôle in the disease, and secondly because the swelling of and the pains in the spleen often are predominant features in the disease, and disappear with Röntgen treatment of the spleen.

A much more difficult problem in the treatment is the *dosing* of the rays.

As is evident from the above and from the reported journals there are three important factors to reckon with when dosing.

In the first place, the aggregate dosage must be fairly large.

My observation II had altogether 75 Sab. through 5 mm. Al. in the course of 5 months on the tubular bones; observation III 68 Sab. through 5 mm. Al. in the course of 6 months. LÜDIN's patient I had 94 Sab. in the course of 7 weeks; patient II 48 Sab., and patient III 142 Sab.

In the second place, some caution must be displayed with the single series treatment. An example of this is GUGGENHEIMER's patient, who received a very vigorous daily irradiation during 3 weeks. There was a violent fall in the number of erythrocytes and the patient became extremely exhausted.

Thirdly, we must take note of what can be seen from my own observations and from several of the journals quoted, viz., that the fall in the number of the red blood corpuscles often does not occur until some weeks after the treatment.

If attention is paid to these factors the following schedule for dosing may perhaps be practicable.

Series treatments of 10 single doses of 2—3 Sabouraud are given on one area. After each series of treatments the patient must be observed for a month. If the number of red corpuscles does not fall below 5 mill. in the course of a month a new series is given. As soon as the number of erythrocytes has reached 5 mill. or under, the treatment is postponed for the time. In most cases the object is achieved by 2—4 series of treatment.

The dosing in the spleen treatment has been a contested question. BÖTTNER maintains that the spleen must be given »Reizdosen». The theoretic foundation for this is, however, somewhat feeble, but it is worse that nobody is capable of giving »Reizdosis» for a splenic tumour to spina.

In the favourable cases, treated with bone and spleen irradiation, mentioned in the literature, the dosage given to the spleen has formed ca. 25—33 % of the total dosage. My observation II had a spleen treatment of ca. 12 Sab. (bone treatment 75 Sab.), and obs. III 8 Sab. (bone treatment 68 Sab.).

From this it perhaps is permitted to conclude that the dosage for the spleen should be between 8 and 16 Sab.

I have to thank my chief, Prof, ROVSING, and the chief of the Röntgen clinic, Dr. PANNER, for permission to publish the cases, and for the interest thay have shown in this work.

SUMMARY

3 observations of patients with polyglobuly have been reported. One of these was cured by Röntgen treatment of the spleen, and the two others by treatment of spleen and bone marrow.

In some cases Röntgen treatment of the spleen alone gives favourable results, but in the majority of cases it has no effects on the polyglobuly.

Vigorous Röntgen irradiation of the bones seems, so far as one can judge at present, to be an effective remedy for polyglobuly.

The main features in the technic of the treatment have been indicated here.

ZUSAMMENFASSUNG

Bericht über 3 beobachtete Fälle von Polyglobulie. Einer von ihnen wurde durch Röntgenbehandlung der Milz und die beiden anderen durch Behandlung der Milz und des Knochenmarks geheilt.

In manchen Fällen gibt die Bestrahlung der Milz allein günstige Resultate, in der Mehrzahl der Fälle aber hat sie keine Wirkung auf die Polyglobulie.

Kräftige Röntgenbestrahlung der Knochen scheint, soweit man bis jetzt urteilen kann, ein wirksames Mittel gegen Polyglobulie zu sein.

Der Artikel bespricht die Hauptzüge in der Technik der Behandlung.

RÉSUMÉ

3 observations de polyglobulie sont communiquées.

Le premier malade a été guéri par le traitement au rayons X appliqués à la rate, les deux autres par l'application à la rate et à la moelle osseuse.

Dans quelques cas, le traitement de la rate seule donne des résultats favorables, mais dans la plupart des cas, la polyglobulie n'en est pas influencée.

Les rayons X, à forte dose, appliqués aux os, semblent, autant que l'on puisse juger à présent, un remède efficace contre la polyglobulie.

Dans le present travail, les éléments principaux de la technique ont été indiqués.

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DIE RÖNTGENOGRAPHIE DES FELSENBEINS

von

L. G. Heilbron, Amsterdam

(Tabula VIII)

Es sind besonders die Untersuchungen von STENVERS,[1] welche die Röntgenographische Einstellung der verschiedenen Teile des Felsenbeins ermöglichten. Die von STENVERS angegebene Einstellungstechnik ist aber ziemlich schwer und es gelingt nicht jedermann mit dieser brauchbare Resultate zu bekommen. Nach genauer Studierung der Topographie des Felsenbeins kommt STENVERS zu folgender Einstellung:

»Man legt den Kopf des Patienten so auf die Platte, dass die sagittale Achse horizontal gerichtet ist. In dieser Stellung kann man den Kopf senken lassen, bis die Nase-Kinn Linie mit der Horizontale der Platte einen bestimmten distalwärts offenen Winkel bildet (meistens 10°). Dann wird der Kopf soviel um seine axiale Achse gedreht, dass die sagittale Achse mit der Horizontale einen Winkel von 45° bildet. In dieser Stellung wird der Kopf mittels einer Klemme fixiert. Dann wird die mit der verlängerten Tube versehene Röhre so eingestellt, dass der Zentralstrahl in vertikaler Richtung durch das Labyrinth fällt. Hierzu legt man seinen Finger auf den Proc. Mast. des zu bestrahlenden Felsenbeins und stellt auf einen Punkt ein, welcher vom Finger einige cm nach der Nase des Patienten zu entfernt liegt. Nun dreht man Tube und Röhre in einer vertikalen Flache um 12° distalwärts, während man, indem man Tube und Röhre

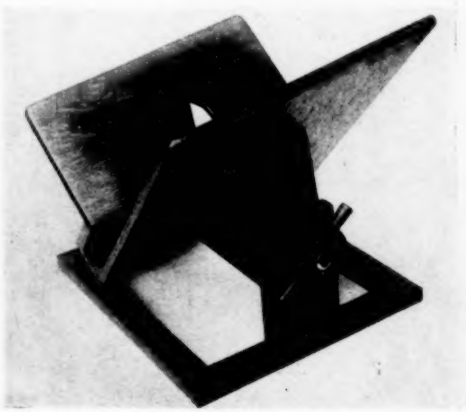

Fig. 1. Zeigt das Böckchen.

[1] H. W. STENVERS. Ueber die Technik der Röntgenologie von Augenhöhle und Felsenbein. Arch. f. Ohren-, Nasen-, und Kehlkopfheilkunde. Bd 103. Heft. 1.

im ganzen distalwärts verschiebt, von neuem auf den Proc. Mast. einstellt.»

Ich habe die Technik in soweit vereinfacht, dass ich ein Böckchen konstruierte, von den *Veifa-Werken* zu beziehen, auf dem der Patient sofort in richtiger Stellung mit dem Kopfe zu liegen kommt. Die Platte liegt jetzt nicht mehr wie bei STENVERS horizontal, doch sie macht mit der horizontale Ebene einen Winkel von 45°. Die geringe kaum merkbare Verzeichnung des Bildes hindert nichts. Wohl liegt jetzt das Felsenbein näher an der Platte und das Bild gewinnt dadurch an Schärfe. Das Böckchen eignet sich für Aufnahmen beider Felsenbeine und ist dazu um seiner Querachse drehbar.

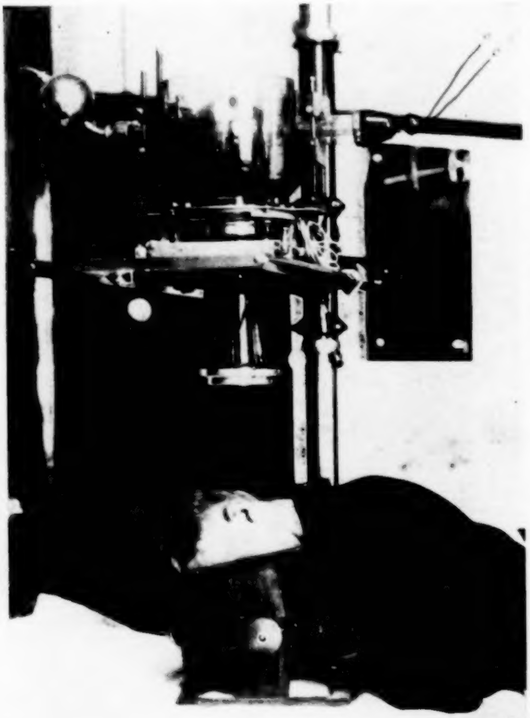

Fig. 2. Patient auf dem Böckchen liegend.

Die Technik ist eine ganz einfache. Man legt auf das Böckchen zuerst die Kasette und darauf den Patient mit seiner Medianebene parallel an die Kasette. Man zentriert darauf die Röhre auf einen Punkt von dem oberliegenden Proc. Mast. 6 cm nach hinten und 3 cm nach oben entfernt, mit dem Fokus 60 cm vom Schädel entfernt. Man kann dabei jede beliebige Blende gebrauchen wenn auf dem Schädel noch eine Bleiplatte liegt mit eine kreisförmigen Öffnung von 7 cm Diameter. Die Sekundärstrahlung im Schädel ist dann minimal.

Fig. 3. Die Anatomie des Felsenbeins nach STENVERS.

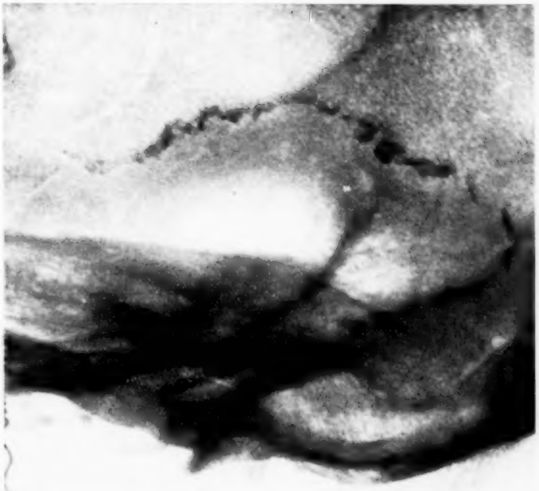

Fig 4. Röntgenaufnahme des Felsenbeins eines Skelettschädels.

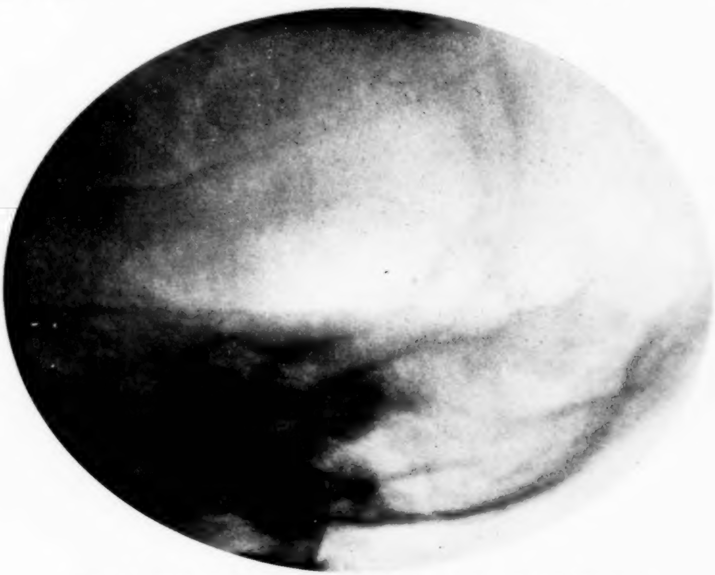

Fig. 5. Röntgenaufnahme des Felsenbeins eines gesunden Mannes.

ZUSAMMENFASSUNG

Stenvers hat nach genauer Studierung der Anatomie des Felsenbeins eine Methode angegeben zur röntgenographischer Darstellung des Labyrinthes, u. s. w., aber seine Weise, den Patienten in gute Stellung zu legen und zu behalten ist sehr schwer, wie auch die Einstellung der Röhre. Verf. hat dann ein Böckchen (Fig. 1) von der A. E. G. fabrizieren lassen, worauf der Kopf bequem und fest liegt. Man braucht die Röhre nur vertikal oberhalb einen bestimmten Punkt (Fig. 2) einzustellen und die Exposition kann gemacht werden.

SUMMARY

Stenvers after exact anatomical study of the os petrosum, developed a method to radiograph the labyrinth etc., but his manner of getting and fixing the patient in a good position is a very difficult one. Also his way getting a good landmark is very troublesome. Therefore the author had an apparatus (Fig. 1) made by the A. E. G. on which the patient lies very comfortably. It is only necessary to cent the tube above the landmark (Fig 2) and the exposure can be made.

RÉSUMÉ

Stenvers après avoir étudié l'anatomie de l'os petrosum a dévelopé un méthode pour radiographie du labyrinthe etc., mais sa manière de faire poser le malade est très difficile, aussi que sa manière de répérage. C'est pourquoi l'auteur fait faire un petit appareil par l'A. E. G. sur lequel le malade est couché très facilement. On n'a qu'entrer le tube audessus du point de répère pour faire l'exposition.

TWO UNUSUAL CASES OF MULTIPLE URETERAL CALCULI

(Reported at the meeting of the Danish Radiological Society held on Oct. 27th, 1921)

by

Kai Wegge

When we are able to diagnose calculus of the ureter by an X-ray examination, this usually applies to single stones and generally to rather small ones. The discovery of very large calculi is a rare occurence, while still rarer is the demonstration of numerous stones in the ureter.

In his »*Experiences of Ureteral Calculus*» (Hospitalstidende 31—33, 1900) Rovsing reported a case in which he removed stones from the ureter, the length of the stones put together being about 18 cm. First of all a small stone was found in the pelvis, followed by two pieces in the ureter, 9 cm. and 4 cm. in length respectively, the fractures of the stones coinciding with one another, while below these a stone of about 5 cm. in length was found, and in close contact with the lowest end of this were two smaller ones.

In »Policlinico» 1905 (Sez. chir. Fasc. 2) Fiori describes a case in which he removed several small stones from the middle third of the pelvic portion of the ureter after separation of the incrusted wall of the ureter.

Apart from these two cases I have not found any others in the literature accessible to me, that resemble the two cases I am going to describe.

One of the cases was observed in the Roentgen clinic of the »Kommunehospital». It was a man of 55 who was admitted to Departement I of the Kommunehospital in Oct. 1921. The patient had been treated in the same Departement in 1905 for a perinephritic abscess on the right side and its tuberculous nature was demonstrated by microscopic examination of a scraping from the fistula. The patient had previously been treated for syphilis and right pulmonary tuberculosis.

Just before admission the patient complained of a little pain on urinating and incontinence of urine at night. On admission the urine was al-

kaline and contained pus. Microscopic examination showed the presence of numbers of short and long. motile rods. There were also white blood corpuscles and a few epithelial cells. A microscopic examination of a 24 hours' sample of urine showed no tubercle bacilli.

The right ureter was easily catheterised and yielded clear urine, whereas on the left side the catheter could only be introduced just inside the ureteral orifice. No flow of urine was observed on this side.

The roentgenogram (fig. 1) shows that there were a very large number of stones in the urinary tract of the left side, two or three being found in the region of the kidney shadow, one of them having the size of a small plum. At the level of the left transverse process of the first lumbar vertebra there is a calculus the size of a small acorn, and exteral to the space between the transverse processes of the 2nd and 3rd lumbar vertebrae there is a calculus as large as a good-sized date-stone. Below the lower border of the transverse process of the 4th lumbar vertebra a number of elongated calculi are to be observed which almost form a cast of the ureter. No stones are to be seen in the bladder.

Fig. 1.

Externally to the space between the right transverse processes of the 3rd and 4th lumbar vertebrae the shadow of a lime calculus almost as large as a pea is seen, which, judging from the general picture, arises from a calculus in the ureter. (In the picture, which was taken obliquely, this shadow is seen projected 2 to 3 cm. higher up, so that the possibility cannot be excluded that the object giving rise to the shadow may lie in front of the ureter).

The other case was a ship-carpenter's apprentice, 16 years of age, who was admitted to Sundby Hospital on the 16. VIII. 20. with the diagnosis of purulent arthritis of the left knee-joint. He is said to have been previously quite well and not to have had anything the matter with the thoracic organs or gastro-intestinal tract nor any signs of disease of the urinary system. He has often had to plane the ship's deck for hours on end, having then to work on his knees and often getting small abrasions on them. He believes he has never had an effusion into the knee-joints.

Four days before admission he suddenly experienced pain and swelling of the left knee which was treated subsequently with hot fomentations.

The temperature on admission was 39. 7°. The left knee was kept flexed at an angle of about 45° and acute pain was caused by moving it. There were signs of recent small excoriations on the knee, the contour of which was partly obliterated, and the skin was hot and red. The day after signs appeared, which were localised in the lowest part of the femur, and it was then considered to be a case of acute osteomyelitis. After the knee-

joint had been punctured and only a small quantity of serous fluid removed, an incision was made on the external aspect of the lowest portion of the femur, where a subperiosteal abcess was discovered. After the removal of a large quantity of sanies the femur was opened up for about 6 cm. of its length.

Subsequently, fresh incisions had to be repeatedly made, and on 11. IX. 20 the left knee-joint was excised.

Pus was first found in the urine on 10. XII. 20, since when it has always been present. In April 1921 the patient began to complain of pain in the right lumbar region and right hypochondrium. The amount of urine passed continued to be rather small.

On 10. V. the patient was unable to pass water, and on examination a calculus about the size of a bean was found in the glandular portion of the urethra and was removed partly in the form of gravel.

Fig. 2.

Since then smaller stones have been passed from time to time.

In the beginning of October the patient was subjected to roentgen examination with the following result (fig. 2):

The left kidney shadow is decidedly increased in size. Coinciding with the site of the pelvis one large and several smaller calculi are to be seen which seem to occupy the greater part of the pelvis. The ureter is full of stones in practically the whole of its extent, the majority of them varying in size from a pea to the kernel of a nut. In the right kidney region the shadows of numerous small calcareous stones are seen which are, roughly, collected in five large groups. In the group lying external to the transverse process of the 3rd lumbar vertebra a single calculus about as large as the kernel of a nut is observed. A little internal to the lowest part of the right sacro-iliac articulation a sharply outlined shadow is seen, presumably also due to a calculus.

As these two roentgenograms differ so markedly from those usually found at an investigation of the urinary tract, I considered it right to publish the cases. This is, however, not the place to discuss the questions whether the pathogenesis in the last case is to be looked upon as a pyelitis with secondary formation of calculi, or whether the disease of the femur and the production of calculi are quite independent of one another.

Finally, I wish to express my thanks to my Chief, Prof. Fischer, for permission to utilize the material of the Roentgen clinic, as well as for the interest shown and the kind help extended by him. I am also indebted to Prof. Poulsen and the Senior Surgeon, Mr. Collin, for allowing me to use the clinical notes.

SUMMARY

The author describes two cases of multiple ureteral calculi. In both cases there is a considerable number of stones, but one of the cases presents a very unusual picture, inasmuch as one of the ureters is closely packed with stones from the pelvis of the kidney right down to the bladder.

ZUSAMMENFASSUNG

Der Autor beschreibt zwei Fälle von multipeln Ureterensteinen. In beiden Fällen findet sich eine beträchtliche Anzahl von Steinen, aber einer der Fälle bietet insoferne ein sehr ungewöhnliches Bild, als einer der Ureteren vom Nierenbecken bis hinunter zu der Blase dicht mit Steinen erfüllt ist.

RÉSUMÉ

L'auteur décrit deux cas de calculs multiples de l'uretère. Dans les deux cas, il y avait un grand nombre de calculs, mais un de ces cas présente l'aspect très rare d'un uretère rempli de calculs à partir du bassinet jusqu'à la vessie.

SECONDARY RAYS IN RADIUM THERAPEUTICS

by

Rolf M. Sievert, Stockholm

Even the very earliest, purely physical experiments with radioactive substances proved that by passing through matter both β and γ rays could produce secondary rays. Later investigations have shown that these phenomena are extremely complicated, and to this day only very few of the problems arising from these causes can be regarded as definitively solved. This must largely be attributed to the tremendous difficulties associated with the setting up of perfectly satisfactory arrangements for experiments.

When making physical researches, attempts are generally made to isolate the phenomenon in question as far as possible. This is however extremely difficult, not to say impossible, when applied to β and especially to γ rays, partly on account of the great penetrating power of the said rays, and partly on account of the secondary effects named, which appear everywhere in the experimental arrangements. By way of example it may be mentioned that to reduce the intensity of the hard γ rays to 1 % of the initial value, a lead screen of no less than 7 cm. thickness is required, and to remove the β rays by the aid of a magnetic field, it is almost impossible to avoid secondary rays emanating from the voluminous magnet required for this purpose.

The physical facts which will naturally prove most interesting to the medical radiologist are primarily those in connection with the fundamentals of all ray therapeutics — the dosage question. A priori it is self-evident that the dosage must depend on the quality and quantity of the rays, and also on the time of application. The biological result of the exposure to the rays must in all probability also depend on the property of the tissue treated [absorption coefficient and sensibility coefficient, Christen (16, 17)]. Before there can be any hope of studying the factors last named successfully, greater lucidity must be obtained as regards the composition and intensity

of the rays able to exercise a biological effect. The primary as well as the secondary rays must then naturally be taken into consideration. Indeed, in some cases, the latter point may with good reason be emphasized as being quite as important for the biological effect as the former one. Unfortunately, when experimentally treating problems to do with this matter, still greater difficulties confront us than at the purely physical researches above alluded to, for in order to be able to draw any conclusions profitable to therapeutics, it is necessary to investigate the generally very complicated cases which occur when treating with radium.

The following pages contain a summary of the results of the purely physical researches in connection with the problem of secondary rays, and also an attempt to draw some conclusions of interest for the medical radiologist, by mathematically and experimentally treating some problems in radium therapeutics.

PHYSICAL FACTS

As is well known, radioactivity is an atomic property and is thus indepedent of the chemical or physical position of the radiant atoms. The secondary phenomena in question also possess, as far as is known, this property, i. e. that atoms of a certain substance have the same power to absorb and emit secondary radiations in whatever chemical or physical condition they may be. These circumstances make absorption and secondary radiation in cases of combined substances generally appear purely additive.

By passing through matter β and γ rays are both able to give rise to secondary β and secondary γ radiation.

When it is a question of transformation from primary to secondary γ rays, the term of »secondary rays» comprises two quite separate groups, viz. fluorescent (characteristic) radiation and scattered (reflected) radiation. The former originates from changes taking place within the atom exposed to the rays, the latter, on the other hand, may be considered to consist of primary rays which by means of atomic forces, have received other movement directions. There is reason to believe that in this case the fluorescent rays need not generally be taken into account, their intensity being so extremely small, in comparison with that of the scattered rays.

Two similar groups may be considered possible even at the transition from primary to secondary β rays, though according to opinion in general a radiation characteristic of the exposed substance may be of subordinate importance.

The transformation from β to γ rays must be considered identical with that of kathode to X-rays.

The secondary β radiation caused by γ rays is analogous to the so-called photo-electric effect which is more or less important at the absorption of nearly all different kinds of electro-magnetic waves.[1]

There is only one of the transformations above stated which for the observations in the subsequent pages need not be taken into account, Starke (77), Davisson (20) and Chadwick (14) having found that the γ rays arising when bombarding a substance with β rays from the radioactive substances here in question (primarily RaB and RaC) are of negligible intensity in comparison with those of the primary γ rays. This seems strange considering the similarity of this case and the phenomena in an X-ray bulb. The matter can however, easily be explained, for the number of β particles is exceedingly small even when using great quantities of radium (for example 1 gr.) as compared with the electrons of the kathode rays in the bulb, and the fact of the rays nevertheless having such powerful ionization and biological effects is due to their enormous velocity. The secondary γ rays to which they give rise are therefore to be compared with extremely hard X-rays of exceedingly slight intensity. In reality Richardson (67) and Hess and Lawson (44) have discovered that characteristic radiations (K and L series) may also be caused by the impact of β rays on metals.

The absorption and scattering of β rays.

The penetrating power of the β particles depends upon the velocity with which they are emitted. The β radiation originating from radium and its disintegration products consists of various components of different velocity. For example, Rutherford and Robinson (71) when examining the magnetic spectrum of RaC have found no fewer than 64 different lines. According to an abstract of v. Baeyer (3) the velocities of the β rays from the uranium and radium groups range between the following values.

UX	Ra	RaB	RaC	RaD
0.48—0.59	0.52—0.65	0.36—0.82	0.63—0.98	0.33—0.39
0.82—0.96				

The absorption of the corresponding rays by aluminium will be seen in table I.

[1] This effect is strongly pronounced especially with ultraviolet rays.

Table I.

Intensity in per cent of the initial value calculated according to HAHN and MEITNER (41), SCHMIDT (73) and MEITNER (64).

mm. of Al	UX	Ra	RaB	RaC	RaD
0.00	100	100	100	100	100
0.01	75	75	45	96	0.5
0.05	39	20	6	82.5	< 0.0000001
0.10	31	5	3.5	69	
0.50	18	< 0.00005	0.25	22	
1.00	8		0.06	9.5	
2.50	1		0.009	1.2	
5.00	0.03		0.0003	0.05	
7.50	0.0005		0.00001	0.0015	
10.00	< 0.000008		< 0.0000003	< 0.00005	

The rapid decrease in the intensity to be found in the first hundredths of a millimeter is due to the soft components being almost completely absorbed. After passing through less than 0.5 mm. aluminium the β rays from Ra and RaD may be considered as almost totally stopped, while those from UX, RaB and RaC are only reduced to 18, 0.25 and 22 % of the initial intensity respectively.

EVE (25), KOVARIK (55) and FRIMAN (30) have made researches with regard to the absorption of the hard β rays in air, and have found the coefficient of absorption to be about 0.004, i. e. the intensity is reduced to half after the transmission of c. 1.5 m. air. The absorption by 10 cm. air can thus be calculated to max. 5 %.

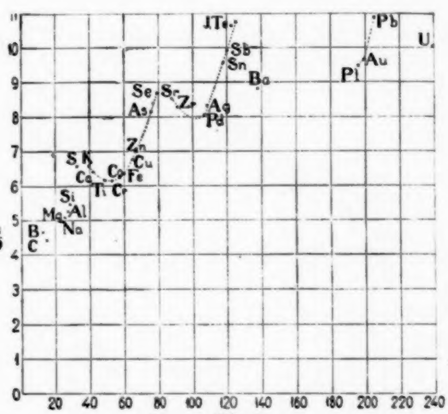

Fig. 1. The relation between the mass absorption coefficient of β rays and the atomic weight according to CROWTHER (19).

CAMPBELL (13), ALLEN (2), SCHMIDT (74), BORODOWSKY (9), and others have obtained very divergent results when studying absorption by liquids. The most reliable results seem to have been obtained by BORODOWSKY, who has verified the validity of the previously

mentioned law of additivity even for liquids and solutions. In his investigations BORODOWSKY has made use of the β rays from a radium preparation, and has found absorption by water to be about $^1/_3$ of that by aluminium. The intensity of the β radiation from RaC may thus be reduced to the half after passing through 1—2 mm. of water.

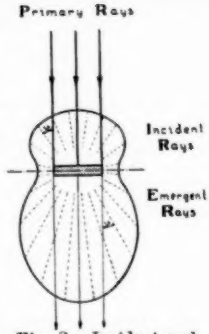

Fig. 2. Incident and emergent rays.

The absorption is moreover dependent on the density and atomic weight of the absorber, inasmuch as the absorption coefficient divided by the density generally decreases with decreasing atomic weight. The curves in fig. 1 which show the relation between $\frac{\mu}{D}$ and the atomic weight are taken from an article by CROWTHER (19).

The absorption appears to be mainly attributed to a reduction in the number of β particles, some of them being stopped in their paths by the atoms of the absorber; a reduction in speed has however also been proved.

When β particles pass through matter, they are reflected diffusely in all directions. The scattered rays emitted from the side of the absorber turned to the source of the rays have been called »incident rays» while those sent out in the opposite direction have received the name of »emergent rays» (see fig. 2).

Even very thin plates (0.001 mm. Al) show a clear scattering effect, which increases with the atomic weight of the substances found in the plate. The phenomena which take place when using thicker plates are however, of greater interest. Numerous investigations have proved that the intensity of the incident rays varies according to the thickness of the plate and the atomic weight. As MC CLELLAND (59, 60) and MC CLELLAND and HACKET (61) have shown, the latter rays play about the same rôle as in the case of the absorption of the β rays, the radiation reflected from a thick plate (10—1 mm. according to the density) producing practically the same variations in the atomic weight

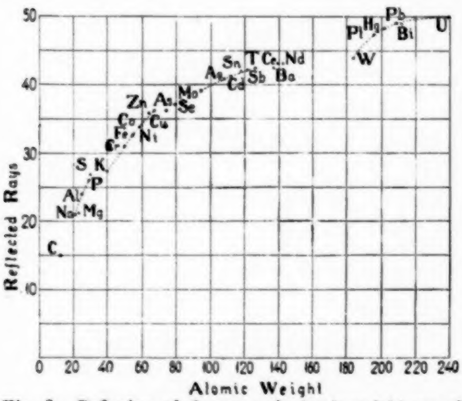

Fig. 3. Reflexion of β rays and atomic weight according to Mc CLELLAND (59).

as $\frac{\mu}{D}$ (see fig. 3). The intensity increases with the thickness of the plate and approaches a limit value as shown in fig. 4 [EVE (22)].

According to EVE (22), MADSEN (63), POUND (65) and others, the emergent rays show a rapid increase with the increase of the thickness of the absorber, to be followed by a fairly pronounced maximum and subsequently a gradual decrease (see curve in fig. 5). The intensity even in this case also increases with the atomic weight.

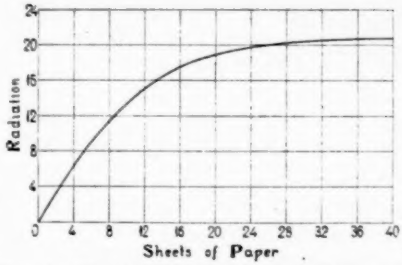

Fig. 4. The incident β rays from thin paper layers of different thickness according to EVE (22).

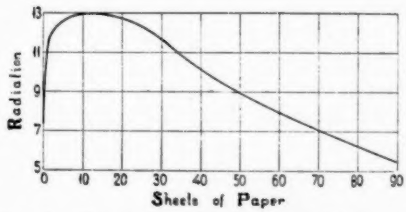

Fig. 5. The emergent β rays from thin paper layers of different thickness according to EVE (22).

Both with the incident as well as with the emergent rays the intensity and hardness diminish according to the size of the angle of scattering (see v in fig. 2). The hardness of the rays reflected seems moreover to be greater with heavy substances than with lighter ones. The velocity of the scattered β particles never exceeds that of the primary rays. The intensity increases with the hardness of the primary rays.

Some of the above made statements are taken from investigations with β rays from uranium. When, however, as in this case, it is a question of rough estimations, they may also be applied to the β radiation from RaB + RaC. This is obvious when comparing the absorption (see table I) of the different radiations.

The absorption and scattering of γ rays.

γ rays sufficiently intense to be of interest in radium therapeutics are emitted solely from RaB and RaC. Up to the present time the spectrum of the γ rays seems only to have been examined by RUTHERFORD and ANDRADE (69, 70). With the aid of a crystal spectrograph they have succeeded in discovering lines lying within the area 0.072—1.37 Å.U.[1] The shortest waves have been measured even after passing through 6 mm. lead, and there is consequently

[1] 1 Å.U. = 0.0000001 mm.

the possibility of these forming the hardest of the most intense rays from RaC. RUTHERFORD (68) has subsequently stated that this cannot be the case, having observed that the absorption coefficient in lead with X-rays having wave lengths 0.085—0.063 (140—200,000 volt at the X-ray bulb) is almost double as great as with hard γ rays. By means of entirely other arrangements for investigation COMPTON (18) has found that the wave length of the hardest γ rays must be below 0.037 Å.U. Theoretical reflections also give minimum values of 0.01—0.04 Å.U.

A great number of investigators have made profound studies of the absorption of the γ rays from RaB and RaC, and much literature has been published on this subject, but here it will be sufficient to quote KOHLRAUSCH's (52) excellent determinations of absorption coefficients.

According to this investigator, the γ radiation from a radium preparation may be considered to consist of three radiation components, viz. K_1, K_2 and K_3, with an initial intensity of 8, 6 and 1. The two hardest, K_1 and K_2, originating from RaC are reduced to half after passing through 53 and 30 mm. aluminium respectively, while on the other hand, the corresponding value for K_3 originating from RaB appears to be 12 mm. By means of KOHLRAUSCH's values for the absorption coefficients, the following table has been arranged, giving a review of the layer thicknesses which diminish the intensity to half of its initial value.

Table II.

The intensity is reduced to its half value by absorbers of the following thicknesses in mm.:

Absorber	K_1	K_2	K_3
Air[1]	c. 120 metres		
H_2O	126	69	35 ?
Al	53	30	12
Zn	22	12	4.8
Fe	19	11	2.3
Cu	17	10	2.5?
Ag	15	7	2 ?
Pb	12.8	4.6	1.5
Au	7.7	3.0	1 ?
Pt	7 ?	2.7?	1 ?

[1] According to CHADWICK (15) and HESS (42).

If μ_1, μ_2 and μ_3 be the absorption coefficients in a certain substance for the three components, we obtain the following formula for the intensity I after passing through d cm. of this substance

$$I = I_1 e^{-\mu_1 d} + I_2 e^{-\mu_2 d} + I_3 e^{-\mu_3 d}$$

where I_1, I_2 and I_3 represent the intensities of K_1, K_2 and K_3 respectively, before passing through d [comp. (75)]. Whether this division into different components of hardness may be considered to have its equivalent in groups of intensive spectral lines or not cannot be discussed here. It is however worthy of note that, as PRELINGER (66) has pointed out, there is reason to believe that the wave lengths for K_1 and K_2 are to be found in the proximity of 0.03 and 0.08 Å.U. respectively. With KOHLRAUSCH's absorption coefficients a hardening effect is obtained similar in size to that long since observed.

According to KOHLRAUSCH, $\frac{\mu}{D}$ (see above) is almost independent of the atomic weight for γ rays when concerning K_1. With K_2, on the other hand, $\frac{\mu}{D}$ presents rather great and irregular variations in the atomic weight, while with K_3 there is reason to believe that there will be still greater irregularities, depending on selective absorption.

Scattered γ radiation forms an analogy to scattered X-rays, and was first observed by EVE (22, 23). It has been found that the incident rays are softer and of less intensity than the emergent rays, a fact which is more pronounced the higher the atomic weight of the absorber [KLEEMAN (51), MADSEN (62), FLORANCE (26, 27), GRAY (38)]. The hardness and the intensity moreover diminish with increasing angle of scattering, in such a manner that a minimum value is obtained at right angles to the direction of the primary rays [BRAGG and MADSEN (11), FLORANCE (27), GRAY (37, 38), KOHLRAUSCH (53, 54)] as seen in fig. 6.

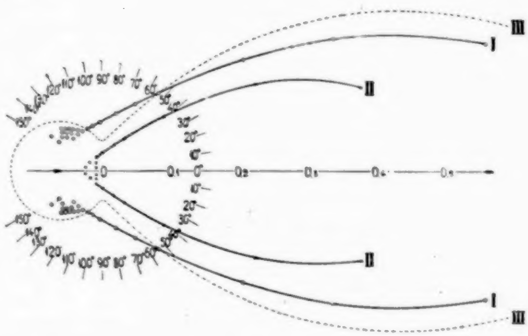

Fig. 6. The distribution of scattered radiation round a carbon radiator according to KOHLRAUSCH (53).
Curve I: total amount of secondary radiation.
» II: secondary radiation absorbed by 3 mm. Pb.
» III: theoretical curve for scattered radiation.

According to FLO-

RANCE (27), GRAY (37), ISHINO (48), HOLTHUSEN (46) and others, the scatterd rays contain a lower percentage of the absorbed primary radiation when using γ rays than when using X-rays [comp. BARKLA (4)].

The following relative values of the intensity of the scattered rays have been observed by FLORANCE (27), the mass per sq. cm. being 0.5 mm. lead.

Table III.

Secondary radiation from different substances.

Radiator	Side of electroscope 2.02 mm. Al.		Side of electroscope 0.84 mm. Pb.	
	Emergent	Incident	Emergent	Incident
C	90	68	80	59
Al	94	69	80	59
Cu	90	70	80	59
Zn	95	76	80	59
Sn	98	76	77	55
Pb	126	105	76	55

Aluminium of 2 mm. thickness is not sufficient protection against secondary β rays, and consequently the variation which will be observed in the first part of the table must be attributed to the facts described on page 277—278. It will thus be seen that the diffuse γ radiation is practically identical for similar weights of different substances. GRAY (37) and FLORANCE (26, 27) have found the scattered rays to be softer than the primary radiation. KOHLRAUSCH (53, 54) has proved that the scattered rays may be supposed to consist of two components corresponding to K_1 and K_2, the changes in quality being explained by the differences in the distribution of these components with regard to the angle of scattering.

The secondary β rays produced by γ rays.

In this case it is also necessary to distinguish between incident and emergent rays. According to ALLEN (1), EVE (22), BIGGS (7) and others, both seem to have the same penetrating power as the primary β rays from the radioactive substance in question. RUTHERFORD, ROBINSON and ROWLINSON (72) have studied the magnetic spectrum of the secondary β rays and have found the quality to be practically independent of the composition of the absorber.

The intensity of the incident rays increases with the thickness of the absorber in a similar manner to that of the scattered primary β rays (comp. fig. 4).

The intensity of the emergent rays increases with the thickness of the absorber, reaches a maximum value and subsequently slowly decreases on account of the γ rays having to pass through a greater part of the absorber before coming so near the surface that the secondary β particles are able to penetrate the remaining layer. In fig. 7 the intensity of the β rays from an aluminium absorber is plotted against the thickness of the absorber according to BRAGG and MADSEN (11). The same investigators have found the maximum of β ray effect with the following thicknesses of the absorber:

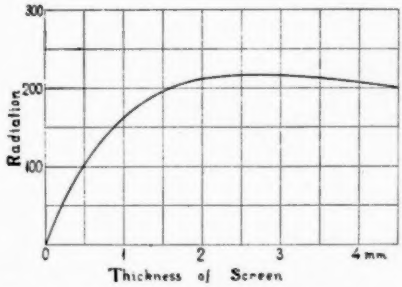

Fig. 7. Emergent β rays produced by γ rays according to BRAGG and MADSEN (11).

Celluloid	Al	Cu	Pb
5	2.5	1.0	0.35.

Table IV shows the results of investigations made by BRAGG and MADSEN (11) with soft and with hard γ rays, the latter being obtained by filtration with 1 cm. lead.

Table IV.

The intensity of secondary β rays produced by γ rays.

Radiator	Soft rays		Hard rays	
	Incident	Emergent	Incident	Emergent
C	170	2 280	58	1 150
Al	280	1 810	120	795
S	340	1 575	154	685
Fe	487	1 350	163	560
Cu	558	—	202	523
Sn	1 051	1 170	333	303
Pb	1 723	2 001	497	470

As regards the relation between the intensity of the incident and the emergent rays, it is obvious that the latter are always con-

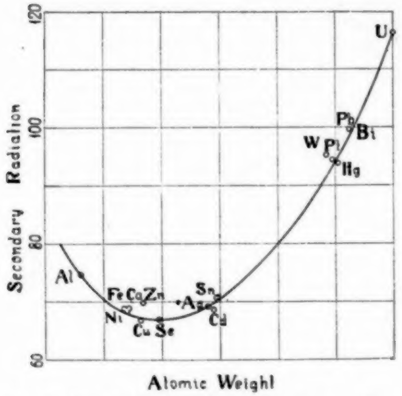

Fig. 8. The intensity of secondary β rays from plates of different substances exposed to γ radiation according to HACKET (40) and EVE (24).

siderably more intense, especially with substances of small atomic weight. The secondary β radiation increases in hardness and intensity with the hardness of the exciting γ rays.

BRAGG and MADSEN (11), KOVARIK (57), EVE (24)[1] and HACKET (40) have examined the relation between the maximum intensity mentioned and the atomic weight of the absorber, and have attained the results given in fig. 8, the source of the rays consisting of radium bromide covered with 2 mm. lead.

SOME SIMPLE MATHEMATICAL LAWS

It may be regarded as useless to endeavour to attack the problem of secondary radiation mathematically with a view to find any fixed rules for the calculation of the secondary radiation which appears when treating with radium. A mathematical study of some simple schematic cases can however give a good view of the general aspect of the question.

For the sake of simplicity let us suppose that the primary rays issue from a small source of radiation, R, and only consist of perfectly homogeneous rays with the absorption coefficient μ', which is then solely dependent on the composition of the absorber. As the absorption factor we can then introduce the quantity

$$A' = e^{-(\mu'_1 d'_1 + \mu'_2 d'_2 + \ldots)} = e^{-\Sigma \mu' d'}$$

which is naturally independent of the order in which the rays penetrate the different layers, d'_1 with the absorption coefficient μ'_1, d'_2 with the absorption coefficient μ'_2, etc.

Again, suppose that a similar indication is used for an arbitrary kind of secondary rays:

$$A'' = e^{-\Sigma \mu'' d''}$$

In the foregoing pages, attention has on several occasions been called to the fact that the intensity of the secondary rays, I'',

[1] Comp. Florance (27).

depends on the angle, φ, between the primary and secondary rays. This relation can be expressed by means of a factor, $f(\varphi)$, which is in all probability dependent on the quality of the primary as well as that of the secondary rays.

If as in fig. 9, we have a little volume element, dv, we thus get the following formula for the arbitrary homogeneous part of the secondary radiation, dI'', with regard to the intensity in P:

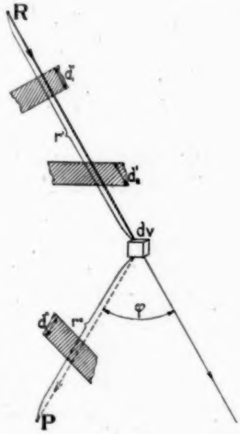

Fig. 9.

$$dI'' = C \cdot \frac{R}{(r')^2} \cdot e^{-\Sigma \mu' d'} \cdot \frac{1}{(r'')^2} \cdot e^{-\Sigma \mu'' d''} \cdot f(\varphi) \cdot dv =$$

$$= C \cdot \frac{R}{(r'r'')^2} \cdot A'(r') \cdot A''(r'') \cdot f(\varphi)\, dv,$$

in which formula R is the number of mgr. radium in the small radiator, $A'(r')$ and $A''(r'')$ the respective absorption factors for the primary and secondary rays for the distances covered, r' and r'', and C is a factor dependent on the character of the matter in dv.

In order to find the total secondary radiation from a volume V in a point P we must naturally add together the contributions for all its small elements with regard to every separate kind of primary (p) and secondary (s) radiation, and we get the expression

$$I'' = \sum_{p,s} \int_V C \cdot \frac{R}{(r'r'')^2} \cdot A'(r') \cdot A''(r'') \cdot f(\varphi) \cdot dv.$$

Some special cases will here be treated, where the integral, which is placed under the sign of summation, can give us some valuable information.

A) The primary source of radiation may be considered as a point; homogeneous primary and secondary rays.

According to the adjoining figure we obtain

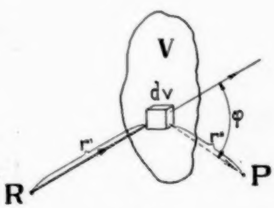

Fig. 10.

$$I'' = \int_V C \cdot \frac{R}{(r'r'')^2} \cdot A'(r') \cdot A''(r'') \cdot f(\varphi) . dv \ldots (1)$$

If we let R and P change places, we find that for every element the factor

$$C \cdot \frac{R}{(r'r'')^2} \cdot f(\varphi)$$

will remain unchanged. It therefore follows that if the factor $A'(r') \cdot A''(r'')$ should also remain unchanged, we must obtain the same value for I'', in spite of R and P having changed places. The condition

$$A'(r') \cdot A''(r'') = e^{-(\Sigma\mu' d' + \Sigma\mu'' d'')} = e^{-(\Sigma\mu' d'' + \Sigma\mu'' d')}$$

is fulfilled for all the positions of dv in the room, if:

a) the absorption be so slight that the two factors can be regarded as $= 1$.

b) $\mu' = \mu''$, i. e. the secondary and primary rays are of the same quality.

In this manner we get

Theorem 1. A certain mass, M, exposed to the rays from a radioactive substance, R, gives, under certain conditions, equal secondary radiation in a point P, whether P and R change places or not. The conditions are: The source of the rays may be considered as a point. The absorption may be neglected or the primary and secondary rays must be of the same quality.

B) Homogeneous primary radiation field, i. e. the primary intensity, I', is the same everywhere; homogeneous primary and secondary radiation.

The secondary radiation, I'', from a homogeneous, thin, spherical layer of the thickness ϱ will then be (see fig. 11).

$$I'' = \int_0^\pi 2 \cdot C \cdot I' \cdot e^{-\Sigma\mu'' d''} \cdot \varrho \cdot f(\varphi) \sin\varphi \cdot d\varphi \quad . \quad . \quad . \quad . \quad (2)$$

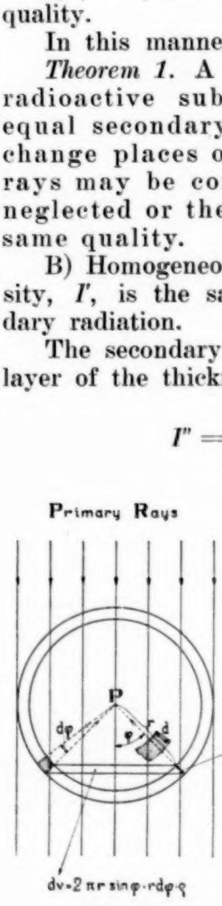

Fig. 11.

In this case, it is obvious that all the factors with the exception of $e^{-\Sigma\mu'' d''}$ are independent of r. $e^{-\Sigma\mu'' d''}$ is ascertained by the absorbing masses lying within the sphere. We thus get

Theorem 2. In a homogeneous radiation field, concentric, spherical layers of one and the same thickness and material give in their common centre a secondary radiation, which, at a given quality of the rays, is only dependent on the absorption in the masses to be found existing inside the layers, not of the radii of the same.

C) The primary source of radiation may be considered as a point; homogeneous primary and secondary rays; P and R coincide (see fig. 12).

The secondary radiation from a volume V will then be

$$I'' = \int_V C \cdot \frac{R}{r^4} \cdot e^{-\Sigma(\mu' + \mu'') d} \cdot dv. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

If r is a constant, i. e. if the secondary rays form part of a spherical layer, we obtain

$$I'' = C \cdot \frac{1}{r^4} \cdot e^{-\Sigma(\mu' + \mu'') d} \cdot V,$$

or

Theorem 3. The contribution in intensity which a point in the immediate vicinity of the source of radiation receives by means of the secondary rays from a given volume, all the elements of which are at the same distance (r) from the point, diminishes if we leave the absorption out of the question with the 4th power of this distance.

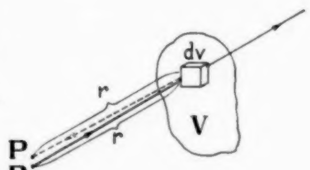

Fig. 12.

To these three theorems may be added a further quite simple formula [comp. BROMMER (12), GLOCKER (32, 33, 35)], which appears to be of interest. If on the line between R and P a secondary radiating volume element, dv, is movable (see fig. 13), we get for its different positions, x, the secondary radiation, dI'',

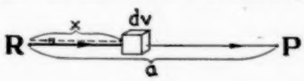

Fig. 13.

$$dI'' = C \frac{R}{(ax - x^2)^2} \cdot e^{-[\mu' x + \mu''(a-x)]} \cdot dv \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

Let dv be replaced by a given volume, V, having small dimensions in comparison with x and $(a-x)$, and let us suppose $\mu' = \mu'' = \mu$ (comp. theorem 1), we then obtain the formula

$$I'' = C' \cdot e^{-\mu a} \cdot \frac{R}{(ax - x^2)^2} = C'' \cdot \frac{1}{(ax - x^2)^2} \quad . \quad . \quad . \quad . \quad . \quad (5)$$

where C'' is a constant factor.

From theorem 1 it follows that I'' must be symmetrical with regard to the normal in the centre point of PR. This is also obvious from fig. 14, which shows I'' as a function of the distance

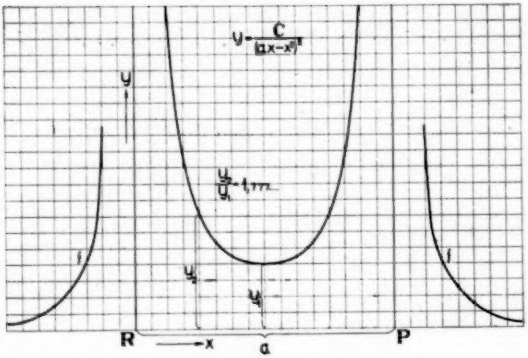

Fig. 14.

x. C has a lesser value for both the parts f_1 and f_2 outside PR than it has for the middle curve, on account of their accordance to incident instead of emergent radiation. In consequence of this the two outer curves are not to be quantitatively compared with the middle part.

EXPERIMENTAL INVESTIGATIONS

All the experiments described below have been made with a compensation apparatus, the construction and properties of which have been explained in a previous paper in this journal (76). The apparatus allows of extremely accurate and rapid intensity determinations according to the ionization method.

A. The ionization chamber (see fig. 21 on page 290) was placed at a distance of 90 mm. from a complex of preparations containing about 200 mgr. of radium element and covered with 2 mm. of lead. The preparations formed a surface turned towards the chamber, the size of which was 30 × 30 mm. Between the source of the rays (R) and the chamber (P) it was possible to move an absorbing screen (L, 45 × 45 mm.) with the aid of a micrometer arrangement, the screen in all its positions being parallel with the surface of R and having its centre of gravity on a straight line between P and R.

The intensity determinations were made partly without and partly with screens of different materials and thicknesses in various positions at PR. The wall of the ionization chamber was made of aluminium $^1/_4$ mm. thick. The results will be seen from the curves in figs. 15—17 and curve III in fig. 18. Without the screen in every case the intensity value 47.20 was obtained.

Curves I and II in fig. 18 were obtained when screening the chamber with 1 mm. lead and with 3 mm. »Kerr»[1] respectively.

[1] Kerr Perfection Impression Compound (Detroit Dental Manufacturing Co., Detroit, U. S. A), a plastic composition containing about 50 % organic and 50 % aluminium-magnesium oxide with small additions of silica, ferric and calcium oxide [comp. EDLING (21)].

If the absciss axles of these curves are moved parallel with themselves to suitable positions, they all attain the same proportions as the middle curve in fig. 14 on page 282.

The moving of the axles merely signifies a substraction of the intensity of the primary rays, the quantity of these rays naturally being the same in all the positions of the screen. Counting from these axles the curves show how the secondary radiation from screen L varies according to the position of the said screen.

It may be argued that the secondary radiation from various objects and from the walls of the room cause great disturbances. The influence of such radiation on ionization measurements has been examined by BROMMER (12), HESS and LAWSON (43) and others. BROMMER has investigated the intensity at a distance of 3 metres from a large quantity of radium with the aid of an electroscope, a thick lead screen being placed in different positions between the radioactive substance and the said instrument. He then found curves entirely different from those seen in fig. 14, a maximum instead of a minimum being obtained. From various experiments BROMMER proved that these divergences must be caused by secondary radiation from the walls of the laboratory. The amount of secondary radiation when compared with the total intensity must largely depend on the distance between the radioactive substance and the electroscope or ionization chamber. A calculation of the intensity of the primary rays gives the relation 1 000 : 1 between the intensities at 9 and 300 cm. distance from the radium. The secondary radiation from the walls must ceteris paribus be of about the same size in both cases. According to BROMMER's measurements, the radiation must consequently be of no importance at all when working with a short distance like this [comp. KEETMAN (49), KOVARIK (57)]. On the other hand, there may be a possibility of error sources on account of secondary radiation from objects in the vicinity of the ionization chamber. The only large surface to be found near the chamber able to cause disturbances of this kind, was a stone slab on which the measuring apparatus was placed. A calculation with the aid of formula (3) shows however, that the secondary radiation from the stone slab will in all probability be below 3 % of the secondary radiation from the screen L in its mean position.

Looking back at the physical facts pointed out in the first part of this paper, we notice the following:

a) From the source of the rays, R, γ and secondary β rays are emitted. The intensity and quality of the former may be calculated without any great errors by the aid of KOHLRAUSCH's values for the initial intensity and the absorption coefficients of the different radia-

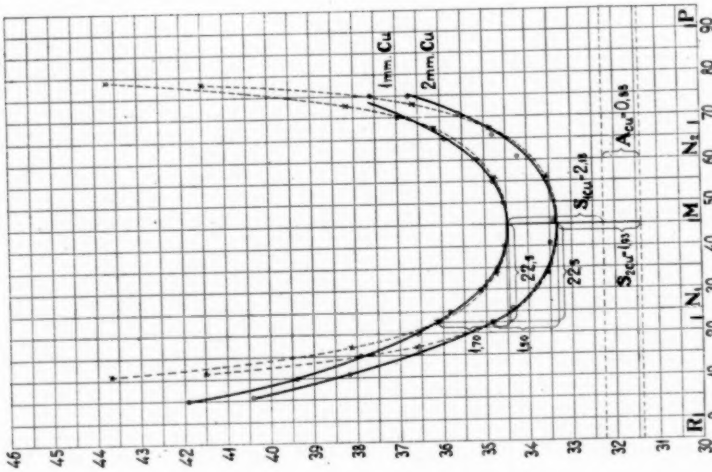

Fig. 16.

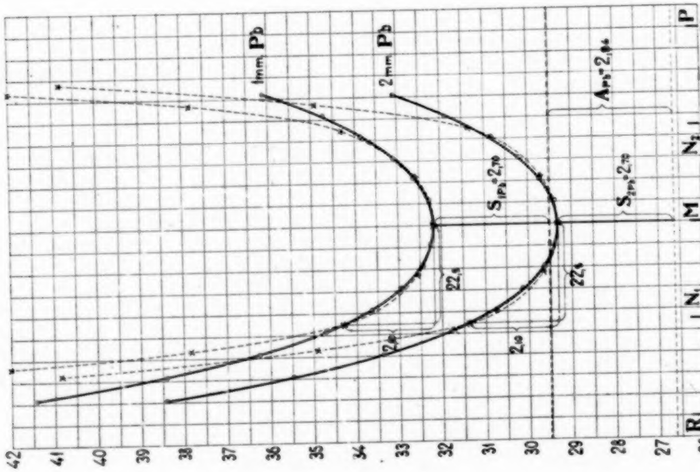

Fig. 15.

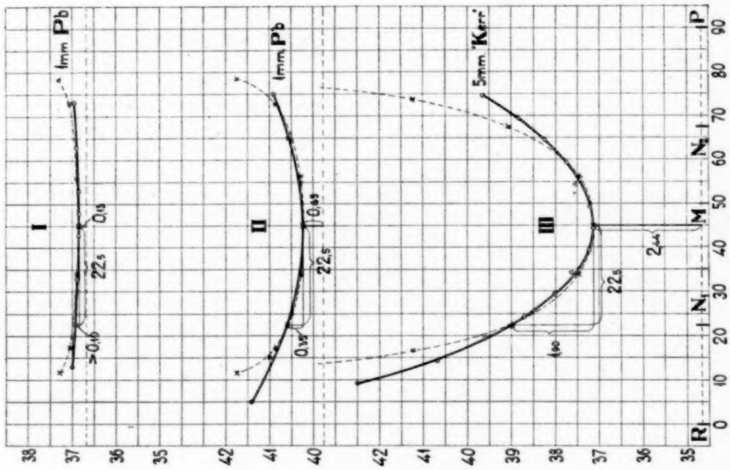

Fig. 18.

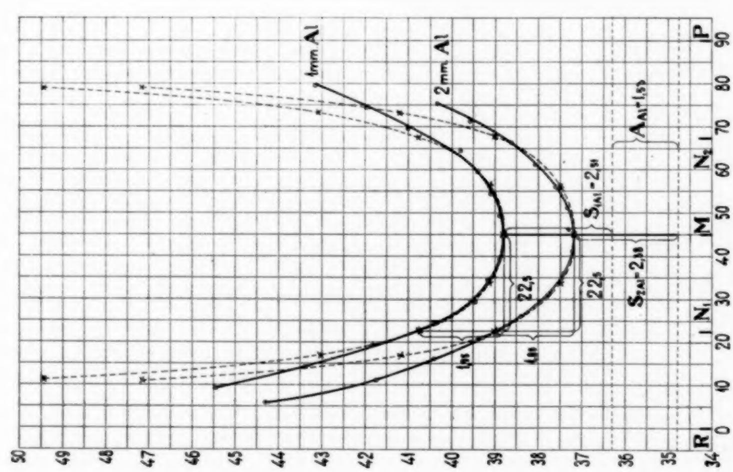

Fig. 17.

tion components [comp. (52, 75)]. The latter must be regarded as originating from a thin layer on the outside of the lead absorber.

b) Screen L more or less completely absorbs the β rays and a small part of the γ rays mentioned in a), at the same time emitting secondary β as well as secondary γ rays.

c) If the walls of the chamber consist of only $^1/_4$ mm. of aluminium, about $^1/_3$ of the β radiation falling on the chamber is able to take part in the ionization; if on the other hand 1 mm. of lead covers the chamber, the β radiation will be completely excluded.

d) The absorption in air may in this case simply be ignored, both with regard to the β and also the γ rays. The condition $\mu' = \mu'' = 0$ is thus fulfilled [comp. theorem 1 and formulae (4) and (5)].

e) A less satisfactory agreement is to be expected with regard to the curves observed and those calculated when in the vicinity of P and R. The intensity of the secondary rays from the peripheral parts of the screen will here be less than that from the centre, the distance as well as the angle of scattering being greater. This will be found to be the case especially in the vicinity of P.

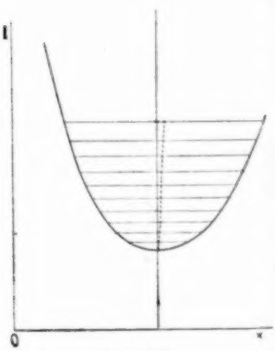

Fig. 19.

In the following calculations it has been supposed that the disturbances mentioned in e) are small in the region N_1—N_2 (see the curves) forming half of the distance between the radioactive substance and the chamber. All the minima may moreover be moved to one and the same position M as has already been done when plotting the curves. The position of those minima was obtained in a graphical manner as shown in fig. 19. By means of formula (5) on page 281 it will be found that the relation between the intensity of the secondary radiation in N and M must be 1.778. From this it will be possible to determine the position of the absciss axles, counting from which the curves should show how the secondary radiation from screen L varies with the distance between L and R (see dotted axles). From a comparison between the curves observed and those calculated (see dotted curves), it is obvious that the latter always lie above the former, this being in accordance with the statements made in e).

It will be seen from the curves in fig. 20 how great a part of the total intensity observed should be attributed to the secondary radiation. Curve I in fig. 18 shows that the intensity of the scattered

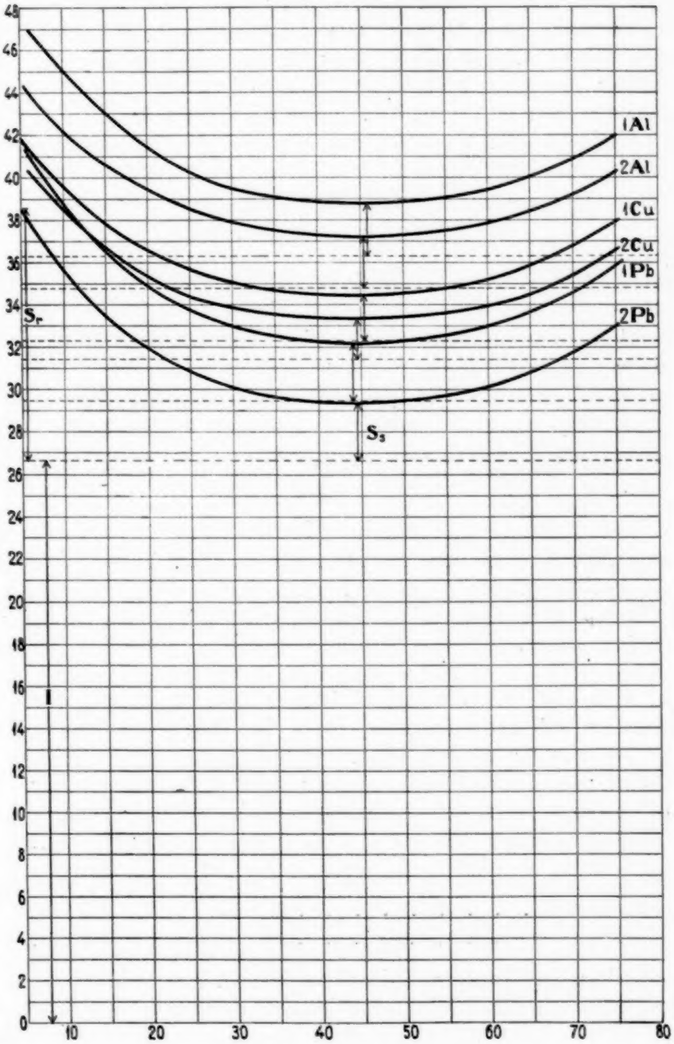

Fig. 20.
I = intensity of the primary rays.
S_s & S_r = » » » secondary » .

γ radiation must be rather small as compared with that of the secondary β radiation, when measuring as mentioned above.

In order to be able to compare the secondary β rays emitted from different substances, the thicknesses of the screens must be near the values giving the maximum of the emergent β rays, i.e. about 2.5 mm. Al, 1 mm. Cu and 0.35 mm. Pb. The distances marked S (see figs. 15—18) which should thus form the relative measure of the secondary β rays from the respective substances are

»Kerr»	Al	Cu	Pb
2.44	2.38	2.18	2.70

As the radiation must mainly be attributed to a very thin layer of the part of L which is turned towards the ionization chamber, a correction must be made according to the absorption of the γ rays in screen L. We thus obtain the relation

»Kerr»	Al	Cu	Pb
0.77	0.74	0.70	1.00

This agrees in the main with HACKET's investigations (comp. fig. 8) which give:

$$0.75 : 0.67 : 1.00$$

Distance A between the dotted axles in figs. 15—17 corresponds to the absorption of the rays in 1 mm. of the respective substances. As regards A_{Pb} this absorption can only be attributed to the γ radiation, the first mm. of the screen absorbing the β radiation completely. According to KOHLRAUSCH, the decrease in intensity in 1 mm. lead is in this case 8.2 % of the initial value. A_{Pb} gives 8.6 % of the same quantity of radiation, so even in this case the agreement seems to be rather satisfactory. A_{Al} and A_{Cu} contain part of the absorption of the β radiation emitted from R, consequently there is reason to believe that these values will be greater than those calculated, this also being the case with regard to aluminium:

	Al	Cu
Observed	4.3 %	3 %
Calculated	2 »	6.2 ».

The absorption in copper being so small, probably depends on some inaccuracy in the determination of the curve obtained with 2 mm. Cu, but then the appearance of this curve differs from those of the others, which will be clearly seen from fig. 16.

If we compare this absorption with the difference between the intensity observed with and without the screen in its mean position, M, we find an astonishing difference. This depends on the β radia-

tion mentioned in a). The β radiation contains no less than about 30 % of the total intensity measured by using an ionization chamber made of 1/4 mm. aluminium. The great increase which characterizes the curves in fig. 15 when the lead screen approaches the radioactive substance makes this evident. The secondary β radiation which strikes the ionization chamber when a lead screen 1 mm. thick is placed just between the source of the rays and the chamber, only amounts to about 8 % of the total intensity.

B. The radioactive substance R and the ionization chamber I were placed in a cylindrical vessel S_2 holding c. 400 cub.cm. as is shown in fig. 21, tube S_1 being taken away. The part of the chamber marked W in the figure could be removed, so that experiments could be made with chambers of different materials and thicknesses.

The ionization current in the chamber was measured with and without water in the vessel. Investigations were made with distances of 10 and 30 mm. and 1 and 2 tubes respectively, each containing 10 mgr. of radium element; at the 10 mm. distance a plane applicator containing 10 mgr. was also used. The tubes were 6.2 mm. long and were furnished with gold and platina filters (=1 mm. lead) and could be put into lead cases 2 mm. thick. The plane applicator was 1 × 1 cm. in size and protected by 1 mm. lead.

The results of the investigations are to be found in table V.

Table V.

a	Applicator	Ion. chamber	Intensity in arbitrary units		Difference in % of the int. without H_2O	Calculated γ absorption according to Kohlrausch
			without H_2O	with H_2O		
10 mm.	1 tube *Pb* 1 mm.	*Cu* 1/1 mm.	47·05	48·20	+2·4	− 8·2
		Al 1/4 »	40·75	44·25	+8·6	
	Plane *Pb* 1 mm.	*Cu* 1/1 »	36·05	36·45	+1·1	
		Al 1/4 »	40·25	37·10	−7·8	
30 mm.	2 tubes *Pb* 1 mm.	*Cu* 1/1 »	24·80	24·45	−1·4	− 18·5 %
		Al 1/1 »	23·60	22·40	−5·1	
		» 1/4 »	24·80	22·60	−8·9	
	2 tubes *Pb* 3 mm.	*Cu* 1/1 »	19·55	19·10	−2·3	− 8·9 %
		» 1/4 »	20·45	20·30	−0·7	
		Al 1/1 »	19·85	19·50	−1·8	
		» 1/4 »	18·60	19·10	+2·5	
		Ivory 2/1 »	18·30	17·70	−3·3	
		» 1/2 »	20·35	20·75	+2·0	

The experimental error in all these determinations was less than 0.5 %. The intensities obtained with different ionization chambers must not be compared with one another, for slight variations in the size existed.

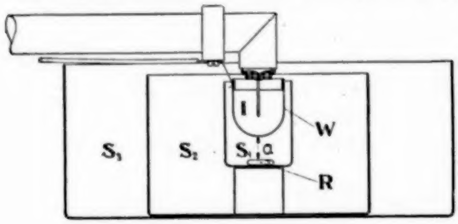

Fig. 21. (1/3 nat. size.)

From the figures in the last two columns it is obvious that the construction of the walls of the chamber is of very great importance when making investigations with secondary rays in liquids. The causes of the apparent irregularities in the differences observed are:

a) Secondary β rays from the surface of the applicator.

b) Secondary β rays from the water in the vicinity of the ionization chamber.

c) Secondary β rays from the walls of the chamber.

The first factor makes the differences greater, the second smaller. If the wall of the chamber is made sufficiently thick for all the β rays falling on it to be absorbed, the above mentioned factors cannot influence the measurement results. In accordance with this, the differences obtained with 1 mm. Cu are much more uniform than with the other chambers.

A rough calculation of the secondary radiation observed with the chamber just mentioned gives the following result:

Table VI.

Filter of the radiator	Distance	Secondary radiation in % of the primary intensity
Pb 1 mm.	10 mm.	10 %
» » »	30 »	17 »
» 3 »	30 »	11 »

C. Three glass vessels, S_1, S_2 and S_3, were put inside each other; in the inner one the radioactive substance R and the ionization chamber I were placed as shown in fig. 21. The inner vessel, S_1, contained water when all the measurements were taken.

Determinations of the intensity were made with and without water in the vessels S_2 and S_3, at the distances of 10 and 30 mm., 1 and 2 of the tubes described in *B* being used. The results will be seen in table VII.

Table VII.

a	Ion. chamber	Intensity in arbitrary units with water in			
		S_1	S_1+S_2	$S_1+S_2+S_3$	S_1+S_3
10 mm.	*Cu* 1/1 mm.	43·00	43·65	43·75	43·10
	Al 1/4 »	38·85	39·90	39·90	38·90
30 mm.	*Cu* 1/1 »	19·00	19·90	19·95	19·10
	Al 1/4 »	19·45	21·00	21·20	19·55

Experiments have been made with different filters (*Pb* 1—3 mm.) at the radioactive substance, and have given practically the same results. In order to form an idea of the amount of secondary radiation originating from the respective volumes of water, table VIII has been constructed.

Table VIII.

a	Ion. chamber	Amount of secondary radiation originating from			$\frac{S_2}{S_3}$
		S_2	S_2+S_3	S_3	
10 mm.	*Cu* 1/1 mm.	1·5 %	1·7 %	0·2 %	7·5
	Al 1/4 »	2·7 »	2.7 »	0·1 »	27
30 mm.	*Cu* 1/1 »	4·7 »	5·0 »	0·5 »	9·4
	Al 1/4 »	8·0 »	9·0 »	0·5 »	16

It is worthy of note that an important difference between the values obtained with various chamber walls will be found here.

With the aid of formula (3) it is possible to approximately calculate the relation between the hard scattered γ radiation from the volumes S_2 and S_3, thus obtaining about 10, which value is of almost the same size as the corresponding relation in table VIII.

When comparing *B* and *C* it will be obvious that the secondary radiation must be mainly attributed to the water column S_1 between the radioactive substance and the ionization chamber, if the distance and filtration be small. According to tables VI and VIII the column named gives about 85 and 70 % of the total amount of secondary radiation when using a filter of 1 mm. lead at a distance of 10 and 30 mm. respectively.

SOME APPLICATIONS

It may often be profitable, when treating problems of secondary radiation as applied to therapeutics, to distinguish between surface and volume effects, the distribution of the radiation being dependent on the absorption in the body which produces the effect.

If the absorption be considerable we have a surface effect, for rays coming from layers under the surface are more or less completely absorbed. Such is the case for example with visible rays from glowing bodies and also with the secondary β radiation from substances of great density (heavy metals).

If the absorption be slight we have a volume effect, for in this case the radiation coming from volume elements lying deep down in the absorber must be taken into consideration. The hardest secondary radiation from substances of comparatively slight density (liquids) gives us an example of this.

Let us imagine a cell or a little collection of cells (P) placed at a rather great distance from the radium applicator (R). We can then apply theorem 2 to the immediate surroundings of P. This part of the tissue may be divided into spherical layers of constant thickness with P as the centre (see fig. 22). It is now evident that the contributions of secondary radiation originating from these layers are of considerably different qualities on account of the absorption. The contributions from the nearest layers contain a great percentage of soft secondary radiation. With increasing radii these rays rapidly decrease, while on the other hand, the hard rays only diminish by a very small percentage, provided that the radii do not exceed a few centimetres.

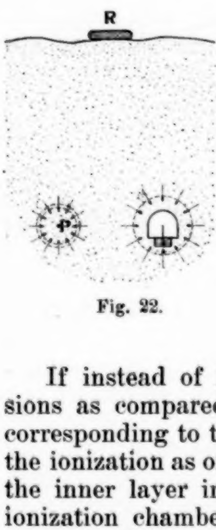

Fig. 22.

If instead of P we have an ionization chamber of small dimensions as compared with the distance PR and embedded in a substance corresponding to the tissue, we can consider some of the contributions to the ionization as originating from similar layers to those just mentioned, the inner layer in the former case corresponding to the inside of the ionization chamber in the latter. If we let the walls of the ionization chamber increase in thickness, it follows that the soft secondary radiation from the substance must be shut out more and more. The intensity of this soft radiation must however be considered as proportional to the intensity of the rays in P or its immediate sur-

roundings. Thus, when measuring the distribution of energy, only the secondary rays seem to be of interest, the penetrative power of which exceeds a minimum, which can to a certain extent be chosen arbitrarily.

Let us suppose that we want to examine the secondary radiation coming from tissue, volumes of water or anything similar, the ionization current being consequently measured both with and without the masses emitting secondary radiation. As has been shown in *B* (see page 289), extremely different values are obtained in such cases, on account of the nature of the wall of the ionization chamber. These differences however, do not only depend on the soft secondary radiation just named, but, as will be seen from the experiments in *A* (see page 288), quite as much on the fact of the filter of the applicator emitting secondary β rays. Here is thus another reason for choosing a comparatively thick wall for the chamber.

The conditions above mentioned clearly show the necessity of employing ionization chambers with moderately thick walls (for example 2—5 mm. ivory) when measuring the distribution of ray intensity. The material should moreover only contain elements of small atomic weight as has been pointed out by FRIEDRICH and KRÖNIG (29) [comp. (8, 16, 17, 29, 30, 45, 49, 56, 63, 78)]. If measurements are made in order to compare rays of different qualities, the size of the chamber must also be taken into consideration [comp. (5, 8, 17, 28, 30, 31, 34, 36, 39, 45, 46, 47, 58)].

Another interesting question is, which parts of tissue must be taken into consideration when estimating the amount of secondary radiation. The experiments mentioned in *C* (see page 290) in the preceding part illustrate this question. It is self-evident that the greater the distance between the applicator and the part exposed the greater will be the percentage of the intensity originating from hard secondary γ radiation. It is obvious from theorem 1 that the conditions in *C* are equivalent to those of a radium application on the skin. The investigations thus give reason to suppose that in this case we need not consider the secondary radiation from volumes outside a sphere with a radius of about the same size as the distance between applicator R and the exposed part P (see fig. 23), provided that the dimensions of the applicator are small as compared with distance PR. The secondary radiation from these parts cannot amount to more than 1—3 % of the total intensity in P. If on the other hand, the radium applicator is completely surrounded by the tissue, this contribution will according to theorem 1 naturally be double as great.

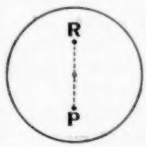

Fig. 23.

The secondary β radiation proved in A is of great importance when treating with radium, these rays being extremely dangerous to the skin. It has been previously pointed out that this radiation may be regarded as mainly coming from the surface of the applicator, and varies witht he filter material (see fig. 8 page 278). It is worthy of note that copper and zinc are among the metals which seem to produce the smallest quantity of secondary β radiation, and in consequence of this fact KEETMAN and MAYER (50) have introduced brass as a standard filter.

It has been repeatedly pointed out that when using plane applicators the distribution of the intensity of the hard γ rays is more satisfactory than when employing small tubes. The secondary β radiation however, increases with the size of the surface of the applicator, a disadvantage with plane applicators which must not be disregarded. The differences between the values obtained with the plane and the tube at a distance of 10 mm., as has been seen in table V, are doubtlessly caused by these rays.

The secondary filter most often used in this country for plastic means of application is the composition called »Kerr», [BERVEN (6), EDLING (21)], which contains about 50 % organic ingredients and 50 % aluminium-magnesium oxide (comp. note on page 282). According to fig. 8 this composition should give somewhat less secondary β radiation than tissue, but a trifle more than aluminium and copper, which fact agrees with the measurements made (see page 288).

When treating at a distance it is possible to diminish the intensity of the secondary β radiation by placing a copper filter (comp. fig. 8) just between the applicator and the skin. According to fig. 16 the soft secondary β radiation thereby diminishes considerably.

SUMMARY

The physical facts which seem to be of interest when studying the problem of secondary radiation in radium therapeutics have been stated.

Some mathematical laws with regard to secondary radiation have been fixed in order to give a general view of the distribution of this radiation.

By means of an instrument previously described in this journal, investigations have been made about

1) The secondary radiation from screens of different materials and thicknesses placed in various positions between a radioactive substance and the ionization chamber.

2) The secondary radiation measured with different kinds of ionization chambers.

3) Secondary radiation from water volumes in different positions.

The results of the measurements in 1) seem to agree with those of other investigators.

Lastly, some questions have been briefly treated which may be of interest in radium therapeutics, the following facts being emphasized:

1) The wall of the ionization chamber should be comparatively thick (for ex. 2—5 mm. ivory) when investigating the distribution of intensity.

2) Secondary radiation is of practically no importance when emitted from tissue outside a sphere with a radius = the distance between the applicator and the part exposed, and with its centre just between these two.

3) When treating at a distance the secondary filter should be placed just between the applicator and the skin, thereby giving a minimum of secondary β radiation.

ZUZAMMENFASSUNG

Es sind die physikalischen Fakta, die für das Studium des Sekundärstrahlenproblems der Therapie von Interesse sein können, zusammengestellt worden.

Einige einfache, mathematische Sätze sind aufgestellt worden, um von der Verteilung der Sekundärstrahlen ein allgemeines Bild zu geben.

Mit Hilfe eines in einem früheren Artikel beschriebenen Messinstrumentes sind über folgende Punkte Untersuchungen gemacht worden:

1) Sekundärstrahlung von Schirmen mit verschiedener Dicke und aus verschiedenem Material in verschiedenen Lagen zwischen Radiumpräparat und Ionisationskammer.

2) Messungen von Sekundärstrahlung bei verschiedener Dicke und verschiedenem Material der Ionisationskammerwände.

3) Sekundärstrahlung von Wassermengen in verschiedenen Lagen.

Die Ergebnisse der unter 1) genannten Messungen sind in guter Übereinstimmung mit früheren Arbeiten.

Zum Schluss werden in Kürze einige Fragen berührt, die in der Radiumtherapie von Interesse sein können, und wird hierbei besonders folgendes hervorgehoben:

1) Die Wand der Ionisationskammer muss bei Intensitätsverteilungs-Untersuchungen verhältnismässig dick sein (z. B. 2—5 mm. Elfenbein).

2) Die Sekundärstrahlung von Massen ausserhalb einer Sphäre, deren Radius gleich dem Abstand zwischen Applicator und dem bestrahlten Teil mit ihrem Mittelpunkt zwischen diesen beiden ist, kann im allgemeinen unberücksichtigt bleiben.

3) Bei Distanzbehandlungen ist es zweckmässig, das Sekundärfilter mitten zwischen Applicator und Haut zu placieren, da hierbei die sekundäre β-Strahlung ein Minimum ist.

RÉSUMÉ

L'auteur signale les faits physiques pouvant être d'intérêt pour l'étude des problèmes de radiation secondaire que présente la thérapeutique.

Il expose quelques thèses mathématiques d'une grande simplicité relatives

à la radiation secondaire dans le but de présenter un aspect général de la distribution de la dite radiation.

A l'aide d'un instrument de mesure dont une description a été faite dans un article précédent, des investigations ont été faites concernant les points ci-après:

1) Radiation secondaire émanant de plaques d'épaisseur et de matière différentes et placées dans des positions diverses entre la préparation radio-active et la chambre d'ionisation.

2) Mesurages de la radiation secondaire, la paroi de la chambre d'ionisation étant d'épaisseur et de matière différentes.

3) Radiation secondaire émanant de volumes d'eau mis dans des positions diverses.

Les mesurages mentionnés sous 1) montrent un bon accord avec les résultats cités dans d'autres travaux.

A la fin de l'article l'auteur traite sommairement de quelques questions pouvant offrir de l'intérêt pour la radium-thérapie, et il fait ressortir particulièrement ce qui suit:

1) Quand on veut déterminer la distribution de l'intensité, on doit avoir une chambre d'ionisation dont la paroi est comparativement épaisse (p. e. ivoire de 2—5 mm).

2) Il n'est pas nécessaire de tenir compte de la radiation secondaire émanant de masses situées hors d'une sphère dont le rayon est égal à la distance entre la préparation radio-active et la partie exposée et dont le centre se trouve á distance égale entre celles-ci.

3) En cas de traitements à distance, le filtre secondaire doit être placé aussi loin de la préparation radio-active que de la peau.

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